The spontaneous flora of the National Botanic Garden of Belgium

(Domein van Bouchout, Meise)

I. Hoste (editor)

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Cover illustration: the historic Bouchout castle in the grounds of the Botanic Garden, with flowering yellow iris (*Iris pseudacorus*) on the foreground. (Photo Q. Groom)

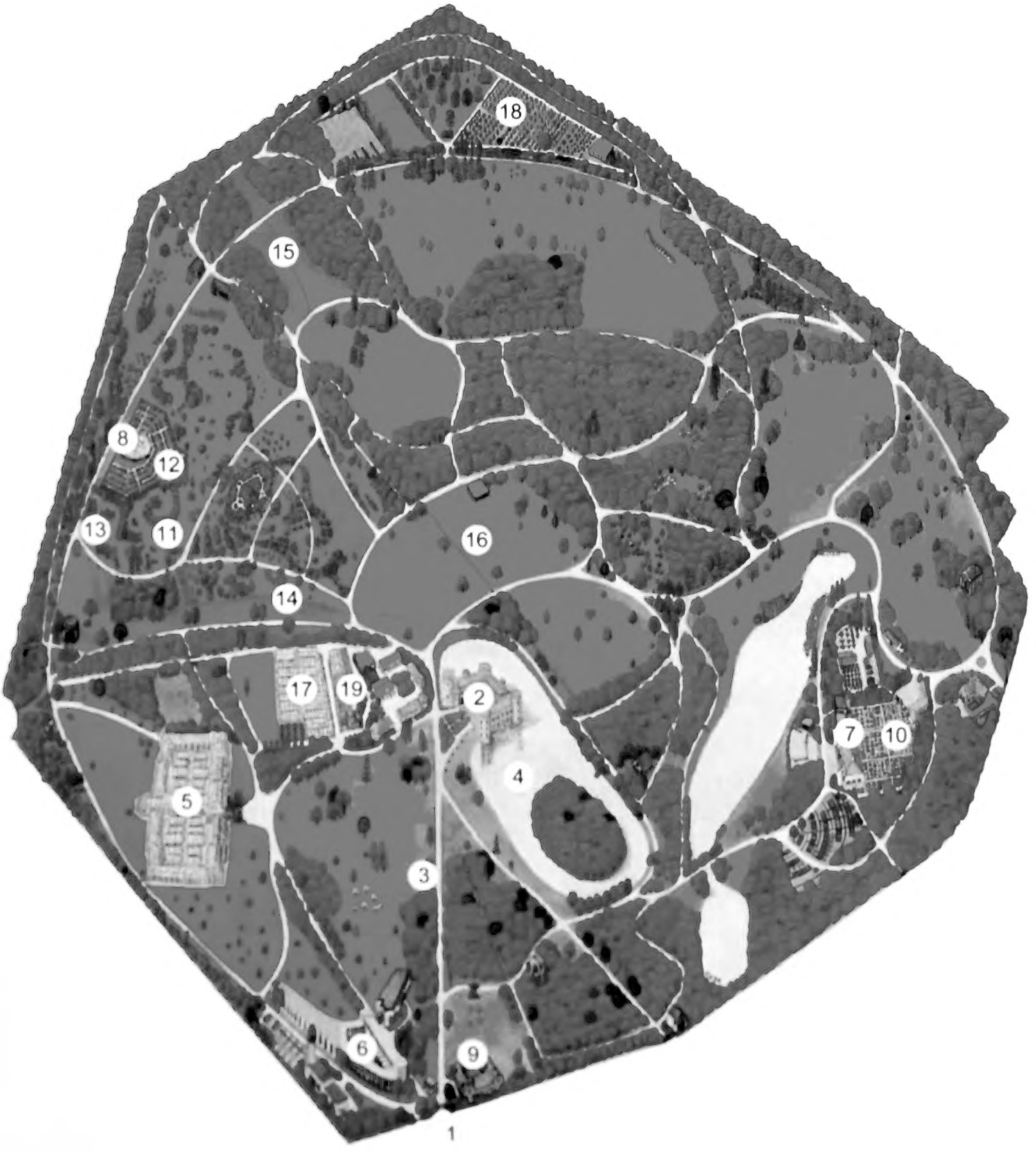
This *Scripta* about the botanical and mycological diversity of the Domain of the National Botanic Garden of Belgium is dedicated to Jan Rammeloo, between 1991 and 2011 enthusiastic director of the Garden.

Map of the National Botanic Garden of Belgium in Meise (prov. Vlaams-Brabant), situated some 10 km northwest of Brussels. (Painting Omer Van de Kerckhove)

The orientation of the map differs from the maps that illustrate the contributions in this volume, in which the north points upward. Rotate the painting 90° counterclockwise for comparison with the illustrations.

The map indicates the location of sites more or less frequently cited in the contributions to this volume. See for more information the Botanic Garden website: http://www.br.fgov.be/

1 Main entrance
2 Bouchout Castle
3 Castle lane
4 Castle lake
5 Plant Palace (greenhouse)
6 Herbarium building
7 Orangery
8 Balat glasshouse
9 Flemish farm
10 Orangery garden
11 Fruticetum
12 Herbetum
13 Coniferetum
14 Machoechel
15 Wild Meise ('De Bilt')
16 Amelvonnebeek (streamlet)
17 Nursery greenhouses
18 Nurseries
19 Office building and canteen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Biodiversity from Ka'apor to ATBI: An absorbing fondness for orchids and other creatures large and small

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Résumé. – Biodiversité de Ka'apor à ATBI : l'attractivité captivante des orchidées et autres organismes grands et petits. Depuis des siècles les taxonomistes et systématiciens étudient la multitude de formes de vie. Notre esquisse historique de cette activité prend comme points de départ les peuples à transmission culturelle purement orale et Theophraste, le père de la science botanique. Elle décrit ensuite le rôle majeur de Linné et aboutit aux projets ATBI (All Taxa Biodiversity Inventory) récemment développés. Aujourd'hui, l'intérêt pour la biodiversité ouvre de nouvelles voies pour la recherche. La faisabilité d'un ATBI du Jardin botanique à Meise est brièvement envisagée.

Samenvatting. – Biodiversiteit van Ka'apor tot ATBI: de fascinerende aantrekkingskracht van orchideeën en andere organismen groot en klein. Sinds vele eeuwen bestuderen taxonomen en systematici de veelvormigheid van het leven. Deze bijdrage biedt hiervan een historisch overzicht, beginnend bij culturen met louter orale kennisoverdracht en de Griekse vader van de botanie Theophrastos, en vervolgens via Linnaeus tot de recente ATBI (All Taxa Biodiversity Inventory) projecten. Vandaag opent de belangstelling voor biodiversiteit nieuwe kansen voor onderzoek. Kort wordt ingegaan op de mogelijkheid van een ATBI voor het Domein van de Plantentuin in Meise.

Introduction

In the 18th century Linnaeus took up the challenge to name (or rename) every living thing. He boasted that no one before him had "written his name on more plants and insects, indeed on the whole of Nature" (Blunt 2001). However, his names represent just a tiny fraction of almost two million described plants and animals today, with furthermore millions left waiting to be discovered, collected, and named. And naming them is just the first part of the task. Thousands of organisms have been given a name only to be all but forgotten soon afterwards. Insufficient funding and a lack of specifically trained biologists prevent in-depth research on all described organisms. Still, these relatively few well-studied plants and animals – minute or monstrously large; useful or threatening; cute, bizarre, or ugly – are all we have to start to grasp the inordinate variety of life on earth. As towards the end of the second millennium more people embraced the idea, a new word was coined for it: biodiversity. This brief survey describes how through the centuries taxonomists and systematists have confronted the teeming multitude of life forms.

The naming of plants: orchids

Biodiversity is a captivating issue for people with widely different backgrounds. Take for example the family Orchidaceae (orchids). Apart from their use as ornamentals, economic botany has little to say about their utilitarian value. Some medicinal applications can be cit-

ed, or the culinary use of vanilla (derived from orchids of genus *Vanilla* from Central America), but this pales if compared with a plant family such as Poaceae (grasses).

In Western Europe the number of orchid species is very modest as compared with the tropics. In the Belgian standard Flora (Lambinon *et al.* 2004) no more than 54 species are described, which represents only 0.24% of c. 22,500 known species worldwide. Furthermore, many species are rare and are only found in highly valued special habitats. This rarity, combined with their beauty, makes orchids popular among naturalists, who like to search for them, photograph them, or observe them as they are visited by insects – inspired, perhaps, by Charles Darwin's 1862 book on *Various Contrivances by which Orchids are Fertilised.* Numerous naturalists even let orchids influence the timing and destination of their next vacation. It feels good to add photographs of a new species or variety to one's 'life list' of orchids observed in the wild. And eventually the records may prove useful to promote the protection of an endangered site.

In the 19th century the Belgian botanist, explorer, horticulturist and successful businessman Jean Jules Linden (1817-1898) went on several expeditions in search of orchids. Living plants of the more attractive species later found their way into the greenhouses of Linden's wealthy clientele (Ceulemans 2006). Today, both commercial and scientific motives still power the search for novelties, but extensive clear-cutting of the forests has turned the quest into a race against the clock. If taxonomists cannot collect and describe them in the near future, we risk losing numerous orchid species before they have been seen or named.

For many people who simply enjoy the beauty of a long lasting windowsill houseplant an orchid is an orchid is an orchid. But that is not enough for flower lovers, naturalists or botanists who want to share their wealth of experiences, observations and knowledge regarding these highly attractive plants with others. What is needed then is a set of unambiguous names and some sort of classification in which to group 'similar' species. People have been tackling these questions for centuries.

The oral and the written

The botanical knowledge of indigenous peoples living in tropical forests is amazing. The Ka'apor in Amazonian Brazil, for instance, use 112 plant species to treat 37 different diseases. Undoubtedly the passing on of this kind of information to the next generation has been going on from long before the first landfall of Columbus in America. A detailed inventory of the Ka'apor plant lexicon has resulted in a list of 768 botanical names according to scientific taxonomic botany. However, because the Ka'apor can be said to be 'lumpers', their lexicon contains a somewhat restricted number of plant names.

Although imposing, the hundreds of plant species that have been given a name by the Ka'apor represent only a fraction of the total plant diversity of the forest. For instance, their plant lexicon mentions only one orchid, and not a conspicuous one at that (*Trigonidium acuminatum*). Two major reasons explain the discrepancy between those plants that are present and those that are named. Indigenous people live in a limited area, and therefore their geographical perspective is restricted. On the other hand, in a culture based on oral transmission of information, there is a kind of 'mental economy' that sets limits to the capacity of the human memory to store information. Therefore it is better not to overburden one's memory with information about species that have no specific use as food, medicine, construction materials, ornamentals, etc. (Balée 1994).

Theophrastos (c. 372-288 B.C.), a man with wide-ranging interests, has often been called the father of botany. He lived in Greece where, just like today's Ka'apor, he was surrounded by a wealth of plant species. In his writings he mentioned that most wild plants simply had no name. This indicates that the early scholars largely disregarded the indigenous flora. Edible and medicinal plants, trees that produce timber or tasty fruit, poisonous or otherwise troublesome plants, or flowers linked with mythology or tradition, were to them far more interesting than the 'useless' wild flora of mountains and woodland, grassland and road verges.

Theophrastos knew that the flora of far away countries differed from what he observed in Greece and was eager to include these plants in his catalogue. But in the end only a limited number of species of foreign origin were included. Among them were plants brought home by people who followed Alexander the Great's army into Asia. Even with these species added, *Historia plantarum* contains descriptions of no more than some 500 plants, of which 80% were cultivated (Pavord 2005). Botany was young and the unexplored parts of the world were huge, and so no one in Greece could have imagined the number of plant species on Earth.

The ways the Ka'apor or Theophrastos looked at plants were largely similar. But Theophrastos had the advantage he could store his information in a written text. In the long run that could, and would, make the difference. People must avoid filling their heads with superfluous information they hardly ever need. But on parchment, paper and hard disk inquisitive people can, from generation to generation, accumulate unprecedented quantities of data without bothering about immediate usefulness.

Expanding knowledge in a shrinking world

In the 18th century, the world, and especially the European scene, had changed dramatically compared with Theophrastos's Greece. From the 15th century explorers have discovered and reconnoitered continents and countries never before visited by Europeans. Along new trade routes numerous commodities, including spices, sugar, tobacco, tea, beaver pelts and textiles, entered Europe. With great interest scientists and collectors also watched for the arrival of natural curiosities, such as minerals, stuffed animal skins, and living or dried plant specimens. At the same time technological progresses created opportunities to discover exceedingly minute and varied life forms. Already in the 17th century Jan Swammerdam (1637-1680) and Antonie van Leeuwenhoek (1632-1723) used microscopes to observe life in a drop of water. Their correspondence with the Royal Society in London was replete with details about the strange world they had discovered. An expanding culture of writing, extensive international correspondence and publishing, typical for the so-called Scientific Revolution, was quickly developing (Jardine 2008).

Carolus Linnaeus (1707-1778; fig. 1) was a committed, self-assured naturalist. Above all he had a penchant for classifying. He understood that for his work on classification he needed to apply the existing system of diagnostic phrases in use for naming and identifying plants. He did not, however, like these long descriptions when he had to compile lists of organisms, for instance during fieldwork. Basically, Linnaeus always wanted to keep things simple and therefore he designed new ways to classify and name plants and animals.

His so-called sexual system was intended as an easy to use method to classify and identify plants, which could be used by both learned men and novices. Its practicality, simplicity, and avoidance of rhetoric and complexity answered to a certain strain in eighteenth-century intellectual taste (Koerner 1996, 1999). It is therefore not surprising that the sexual system was soon adopted in many eighteenth- and nineteenth-century floras that aimed at an audience not restricted to academicians. It was devised as a practical tool, not a grand theory. Linnaeus was aware that his system did not mirror nature's actual kinships, but that was not his primary concern. He humbly conceded in a letter to the Swiss naturalist Albrecht von Haller (1707-1778) that "Therefore, if you establish a natural method, I shall admit it" (Koerner 1999). Among scientists the artificial system was soon replaced with a 'natural' classification, but among amateur botanists it survived into the 20th century, if usually only as an additional shorthand key next to a more up-to-date key based on a natural classificatory system.

The second of Linnaeus's innovations concerned the naming of organisms. He originally conceived his binomials (or *nomina trivialia*) as a means to create a simple language and to avoid the use of long phrases. As a two-word code, binomials could be used by, for instance, the explorers Linnaeus sent on botanical ex-

peditions. He himself only understood the importance of his binomials toward the end of his life, but today they have become the universal standard method in science for naming plants and animals (Koerner 1999). Thanks to him botanists were no longer forced into memorizing the pre-Linnaean name *Solanum caule inermi herbaceo, foliis pinnatis integerrimis* for the potato. Today scientists simply call this plant *Solanum tuberosum* L.

Figure 1. Bust of Carolus Linnaeus (1707-1778) at the herbarium building of the National Botanic Garden of Belgium. His system of binomials remains to this day the universal standard for naming plants and animals.

With these tools at hand Linnaeus set out to classify and name all living creatures and invent names and epithets for every single genus and species. Of course, thousands of species had already been given one or more scientific names, or vernacular names in a variety of languages, but that was not enough. What Linnaeus had in mind was a single and universally accepted scientific name for every species in his classification, although he also paid attention to existing synonyms. It was a huge task, but he wanted to see and verify everything for himself. As he explained in *Species plantarum* in 1753, "Plants not seen by me I have excluded here, since so many times I have been fooled by authors..." (Koerner 1999).

Quite often the names invented by Linnaeus reveal something of his life and character. The young Linnaeus, a pupil of Olof Rudbeck the Younger (1660-1740), was overjoyed when, in 1730, he became a tutor to Johan Olof Rudbeck (1711-1790). In Johan Olof's home Linnaeus had access to the rich botanical library of Olof, who was Johan Olof's father and the formal holder of Uppsala University's chair in medical botany. It is therefore not surprising that a grateful Linnaeus chose *Rudbeckia* as the name for a North American genus that contains some very attractive flowers to immortalize the name of his teacher: "Its rayed flowers will bear witness that you shone among savants like the sun among the stars..." (Koerner 1999, Blunt 2001). The story behind *Aphanus rolandri*, a seed bug, exposes a different state of mind. Daniel Rolander was one of Linnaeus's so-called apostles. He travelled to Surinam and returned home with thousands of specimens. Following a conflict, Rolander refused to hand over his collections to Linnaeus, who later retaliated by linking Rolander's name with a bug of genus *Aphanus*, which is Greek for ignoble and obscure (Dunn 2009*).

Linnaeus was convinced he could meet the ambitious challenge he had set to himself to name all common things. As Dunn (2009) puts it, "He was mad in a way, but brilliant too, in his obsession." Looking back from our early 21st century outlook, with almost two million described species, "mad" seems to be the right word indeed. But Linnaeus had no idea of what lay ahead. He was himself not a great traveller and explorer, but he convinced young explorers to make long and exacting voyages to collect botanical specimens. Five of these 17 trav-

* Dunn's book is recommended as a non-technical and well-written narrative of how biodiversity has been and is still being discovered, named and classified today.

ellers were never to return, but most of them brought back thousands of specimens (Blunt 2001). Linnaeus had expected that his 'apostles' would procure him with the necessary collections to fill in the remaining gaps in his classification. This proved wrong! Life turned out to be much more varied than Linnaeus had imagined. Still, the only way was the way forward, and so he sorted and named the incoming collections. In the end, his classification comprised some 9,000 plant species.

In 1763, based on gross calculations, Linnaeus speculated that the world had 20,000 plant species, 3,000 worms, 12,000 insects, 200 amphibious animals, 2,600 fishes, 2,000 birds, and 200 mammals, or a total of 40,000 species of living organisms. In short time this estimate would be disproved as more and more new species were collected and described (Koerner 1999). In 1847 P.-H. Gonnet, author of a *Flore élémentaire de la France*, commented on the steeply rising numbers of described plants: 9,000 in 1759, 25,000 in 1800, 80,000 in 1840, and soon it would rise to 100,000. A somewhat troubled Gonnet concluded that, "Cette effrayante progression démontre la nécessité d'une méthode qui puisse, comme le fil d'Ariane, guider l'étudiant dans le labyrinthe du règne végétal."

Flowering and eclipse of haystack science

For a long time collecting, describing, naming and classifying of new plant species had constituted the core business of botanists. In the 19th century, however, new fields of inquiry, such as physiology and anatomy, became serious rivals and threatened to marginalize traditional botany. In 1848 the surgeon and naturalist Edwin Lankester (1814-1874) spoke of "the ship-loads of dried vegetables (that) were deposited in the museums of Europe," and he lamented that "these haystacks" were giving the science of botany "a repulsive character" (Endersby 2008). Dark clouds were looming on the horizon. Perhaps there were too many species to realize Linnaeus's dream to name every living thing on earth and to allocate each creature its due place in an all-embracing classification system.

In those days nobody could imagine a single unified project to name all organisms – plants as well as animals. Since the days of Swammerdam and Van Leeuwenhoek very little progress had been made in the realm of unicellular life. Large groups of invertebrates were neglected too, and it was generally accepted that the depths of the oceans were completely devoid of life. On the other hand, much energy was spent in efforts to arrive at a perfect catalogue and classification system for the phanerogams of the world. During his travels in India and Sikkim, Joseph Dalton Hooker (1817-1911), with the help of Thomas Thomson (1817-1878), made extensive collections that eventually included nearly 7,000 species (Gribbin & Gribbin 2008).

The task of identifying, naming and classifying his own botanical treasures and those of other naturalists from all over the globe, proved tough. In the introduction to *Flora Indica* Hooker lamented the lack of a "philosophical" approach of the species problem in the works of many botanists, and also the unprecedented proliferation of new descriptions of genera and species that were all too often based on "trivial characters". The resulting "depreciated state of systematic botany," Hooker warned, threatened to scare away intelligent students into other disciplines (Hooker & Thomson 1855; on 19th century 'philosophical botany', see Endersby 2008).

Thorough steps were required to prevent taxonomic botany from becoming a quagmire of new names, synonyms, and clashing opinions on classification or the 'true' nature of species. At the request of the 1867 International Botanical Congress in Paris Alphonse De Candolle (1806-1893) published *Lois de la nomenclature botanique* (De Candolle 1867). Another cornerstone publication, the three-volume *Genera Plantarum*, was prepared between 1862 and 1883 by George Bentham (1800-1884) and J.D. Hooker. It contained detailed descriptions of 7,569 genera of seed plants. Between 1893 and 1895 J.D. Hooker directed and supervised the compilation of *Index Kewensis Plantarum Phanerogamarum*, an index to the names and authorities of all known flowering plants; sup-

plementary volumes have subsequently been published throughout the 20th century.

In the 20th century taxonomy lost much of its former lustre. Taxonomists had hard times to compete with the younger generations of scientists who were attracted by alternative disciplines and approaches within biology, such as ecology, evolutionary biology, genetics, nature conservation and restoration, etc. As the century drew to a close, Wilson (1988) reckoned that probably no more than 1,500 professional systematists were competent to deal with the millions of species found in the humid tropic forests. And worse, Wilson added, their numbers might be dropping due to decreased professional opportunities, reduced funding for research, and the assignment of a higher priority to other disciplines.

Let there be light again: biodiversity

Looking back, one gets the impression that the decades before c. 1980 were the darkest hour of the night, the last hour before the dawn. From the late 1980s on the newly coined word 'biodiversity' started to pop up in scientific publications by ecologists and conservationists, in the popular press, and in reports and recommendations intended for decision makers. Confronted with the accelerating loss of biological diversity, the simple question "How many species are there?" was increasingly getting renewed attention. Yet today nobody knows how fast diversity is declining or which part of it is threatened. Who better to ask than the taxonomists? The problem is, however, that almost a quarter of a century after Wilson's lament job opportunities, especially for taxonomists studying a range of obscure taxa, are still declining, potentially causing a loss of knowledge not yet recorded in the scientific literature (McClain 2011).

As for the moment, taxonomists can only humbly recognize that precise answers cannot be expected in the near future. In the past few decades we have only just begun to explore life at the deep ocean floor. A varied range of life forms has been discovered in the vicinity of seep-sea vents, where microbes use hydrogen sulfide as an energy source. Life has even been found deep under our feet, in rock samples brought to the surface by drilling operations. Pending more exploration nobody can tell how varied and widespread these microbial life forms will turn out to be (Dunn 2009).

The number of described biota totals c. 1,950,000 species. This includes c. 310,000 Plantae, c. 100,000 Fungi (a poorly known group), and almost 1,500,000 Animalia. Roughly speaking, half of all biota are insects, and of these more than one third are beetles (Noordijk *et al.* 2010). This bewildering diversity of beetle species is what geneticist J.B.S. Haldane (1892-1964) had in mind when he said that God must have had an inordinate fondness for beetles. As to the number of not yet described organisms, educated guesses vary from a few million to several dozen million species. Perhaps the most famous calculation is the one by Terry Erwin, who, in 1982, concluded that 30 million species of arthropods alone dwell in tropical rain forests. He based his estimate on beetles he collected in Panama (Erwin 1982, Gould 1996).

Small-scale in-depth surveys: *All Taxa Biodiversity Inventories* (ATBI)

Linnaeus may have been convinced that naming every living species on earth was feasible in the more or less near future. The more we discover, however, the further out of reach the finish line seems to recede. Perhaps it would make sense to split the task into smaller units. In 1992, Jim Edwards, of the U.S. National Science Foundation, proposed to fund a project to do something crazy like, say, finding all the species in some place. Naturalist and eminent ecologist Dan Janzen took up the challenge and worked out a project for an inventory of the Guanacaste reserve (Costa Rica). Perhaps it was hubris, but Janzen was convinced that, given the collaboration of numerous PhDs, the project was scientifically sound. Unfortunately, a lack of funding prevented it from taking wings (Dunn 2009). But all was not lost, while others would soon pick up the central idea of all taxa inventories.

It is often said that Janzen's project was the first *All Taxa Biodiversity Inventory* (ATBI) project, but at least one precursor is worth mentioning. In the early 20th century the Irish naturalist and historian R.L. Praeger (1865-1953) was the driver behind an ambitious project to make a complete survey of the history, culture, fauna and flora of Clare Island, situated at the west coast of Ireland. Between 1909 and 1911, one hundred researchers, most of them Irish and British, but also a few from Germany, Switzerland and Denmark, "ransacked" – to use Praeger's word! – the island. Although Clare Island is a barren and wind-swept environment largely covered by unproductive peat bog, the results exceeded all expectations. In all, 5,269 animals (of which 1253 new to Ireland and 109 new to science) and 3,219 'plants' (of which 585 new to Ireland and eleven new to science) were recorded (Praeger 1937). According to M.D. Guiry (1997) the Clare Island Survey seemed to have marked the end of such all-encompassing ventures. At the moment he wrote these words, however, a 'New Survey of Clare Island' was being carried out with the overall aim of assessing the changes to the environment and turnover of species on the island (see e.g. http://www.ria.ie/Our-Work/Research/NSCI.aspx). Like the former one, the new survey has a very broad scope that includes archaeology, history and culture, geology, botany, and zoology.

Without referring to the term ATBI, numerous projects have recently pursued a similar goal, not just for the 'fun' of compiling species lists, but also with the aim of developing taxonomic information in an ecological, conservation and educational context (White & Langdon 2006). The idea of compiling lists of the biodiversity of a small area appeals to the imagination of both amateur naturalists and academic biologists or conservationists. Depending on available financial and/or scientific support, initiatives range from very modest to very ambitious. An example of the latter is the Guanacaste-inspired ATBI of the Great Smoky Mountains National Park in the United States, underway since 1997 and largely based on financial support from Discover Life in America (http://www. dlia.org/). Closer to home, a local nature study group has managed to list over 3,000 'plants' (including Fungi) and animals from a forested recreational provincial domain near Eeklo (Flanders, Belgium) (http://www.nlmeetjesland.be/inventarishetleen).

Two examples from the Netherlands are also worth mentioning. Kaaistoep, near Tilburg (province of Noord-Brabant), is the name of a nature restoration area that consists of heaths, woodland and former farmland. Its fauna and flora have been studied intensively since 1995, resulting in over 6,850 recorded species (http://www2.knnv.nl/tilburg/?page=22; Noordijk *et al.* 2010). In Leiden, the area around Naturalis (the Dutch natural history museum) was explored for only a short time during 2008. Unexpectedly, the 91 participating naturalists together managed to list 1,573 multicellular species in an urbanized area no larger than 7 ha. The inventory even yielded a Hymenoptera from genus *Rhysipolis* that was new to science (Smit *et al.* 2009, Smit & Reemer 2009, Noordijk *et al.* 2010).

Biodiversity and the National Botanic Garden of Belgium

Due to King Leopold II's colonial initiatives in Central Africa, Belgian scientists were drawn into new research projects. From the last quarter of the 19th century on, Belgian botanists played an important role in naming and classifying the extremely rich flora of Congo, based on extensive herbarium collections stored at the National Botanic Garden of Belgium in Brussels. During their fruitful careers Emile De Wildeman (1866-1947), Théophile Durand (1855-1912) and Walter Robyns (1901-1986) together named some 4,600 African plants.

After the relocation of the Botanic Garden to outside Brussels, scientists have continued their task of cataloguing 'plant' life, including – according to current classifications – fungi, 'algae' (especially diatoms; today Bacillariophyceae), mosses (today Marchantiophyta, Anthocerophyta and Bryophyta) and vascular plants (today Tracheophyta). In 1973 the scientists exchanged their offices in Brussels

for the Botanic Garden buildings situated in a former Royal Domain in Meise, a village some 10 km northwest of the capital. Covering 92 ha, the Domain today houses a collection of approximately 18,000 living plant species. The varied environment of the Botanic Garden furthermore contains a rich spontaneous fauna and flora, and preserves some very attractive semi-natural vegetation.

For a long time, scientists paid little attention to the biodiversity of the Domain, preferring instead the study of the huge herbarium collections which had been shipped from Brussels to Meise, or doing fieldwork in other parts of the country or abroad. Around 1990 things started to change. A small group of mycologists, including people working at the Botanic Garden as well as amateurs, were the first to realize that the Domain was rich in biodiversity and worthy of close scrutiny. One person in particular, the Antwerp amateur mycologist Hubert Demeulder, made extensive collections and inventory lists. In the past decade knowledge about the vascular plants of the Domain has been greatly increased through the inventory work by Anne Ronse. Also during the last decade the remarkable variety of microhabitats in the Botanic Garden has incited lichenologists to make an inventory of its lichen flora.

The Decade of Biodiversity

The United Nations have proclaimed 2011-2020 the *Decade of Biodiversity*. So, why not use this initiative to turn the Botanic Garden into a meeting point for amateur naturalists and professional scientists with an interest in biodiversity studies? Although almost exclusively restricted to 'plant' life, the wide array of contributions to this *Scripta Botanica Belgica* forms a good basis for an ATBI that would also include animal life. Several of the groups mentioned here are treated in more detail in other contributions to this *Scripta*.

No catalogue is available, yet the number of macromycetes recorded so far from the Botanic Garden can be estimated at 700-750 species. Less than 5 % of these are parasites, 60-65 % are saprotrophs, and 30-35 % are ectomycorrhizal fungi (pers. comm. A. De Kesel). Among the ectomycorrhizal fungi 52 Red List species have been recorded (Van de Kerckhove 2011). The large group of micromycetes has received much less attention, with the exception of Laboulbeniales with 33 species recorded from the Botanic Garden (De Kesel & Gerstmans 2011). With 175 listed lichens and 14 lichenicolous fungi, well-studied in the last few years, the Botanic Garden is the richest site in Flanders (Van den Broeck & Ertz 2011). Eighty-five species of myxomycetes have been recorded in the Botanic Garden. This is about 43 % of the species known in Flanders and Brussels, cited by Walleyn & Vandeven (2006). An ongoing study of the occurrence of protostelids in cultures of aerial litter (dead but still attached plant parts) produced thus far 15 of the 32 species known worldwide. Furthermore, one variety and 5 unidentified taxa (possibly undescribed) were also recorded (de Haan 2011). These are the first records of this primitive group of slime molds in Belgium.

Since 2000, 586 vascular plant species have been recorded, of which 60 % are considered to be truly indigenous. Other groups that can be distinguished in the complex and highly disturbed setting of a botanic garden include garden escapes, external neophytes, deliberate introductions and so-called 'stinsen plants', and a small category of wood lawn neophytes (Ronse 2011a-e, Ronse & Leten 2011).

Other plant groups still require much more fieldwork. Two groups have been studied only locally: 63 diatom taxa have been recorded from the small pool in the middle of the herbarium building (Van de Vijver & Compère 2011), and 27 mosses and liverworts have been listed from the pavement area that surrounds the pool of the herbarium building (Hoste & Geerinck 2011).

In general, animals have so far received little attention. In the past few years at least some 65 bird species have been observed (Q. Groom; pers. comm. M. Segers, *Vogelwerkgroep Noordwest-Brabant*). The huge group of insects and other invertebrates has only just been touched upon. Linked with his study of Laboulbeniales, A. De Kesel (pers. comm.) re-

corded 53 Carabidae. Also within the extremely diversified order of Coleoptera, 11 species of the attractive family of Coccinellidae have been recorded (pers. comm. A. Ronse and Q. Groom). Since 1997, 153 moths and 18 butterflies have been identified (pers. comm. O. Van de Kerckhove). And finally there is the diversified group of gall causing organisms which so far has yielded 71 species (Groom 2011a).

The Botanic Garden undoubtedly has a rich spontaneous fauna and flora, houses quite a number of Red List fungi, offers opportunities for interesting studies on rarities such as *Cirsium ×hybridum* (Groom 2001b), etc. That fieldwork carried out for this *Scripta* yielded two diatom species new to science, came as a pleasant surprise (Van de Vijver & Compère 2011). Observations on the rust *Frommeëlla mexicana*, not before recorded from Belgium, underscore that the Domain offers opportunities to study 'microcosms' in which both indigenous and alien species interact (Fraiture 2011). In all, much remains to be done. A small alien ant that has been thriving for years in the greenhouses has been identified as *Iridomyrmex humilis* (Argentine ant), but the indigenous ants of the Botanic Garden have never been studied. We simply know close to nothing about complete families and orders of organisms in the Garden.

Surely Shakespeare's Hamlet had a point: "There are more things in heaven and earth *(and in the Botanic Garden)*... than are dreamt of in your philosophy."

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References

Balée W. (1994) – Footprints of the forest. Ka'apor ethnobotany – The historical ecology of plant utilization by an Amazonian people. New York, Columbia Univ. Press.

Blunt W. (2001) – The complete naturalist. A life of Linnaeus. London, Frances Lincoln.

Ceulemans N. (2006) – Jean Linden. Explorer, master of the orchids. Brussels, Fonds Mercator.

De Candolle A. (1867) – Lois de la nomenclature botanique. Paris, V. Masson et Fils.

de Haan M. (2011) – First records of Protostelids and Myxomycetes on aerial litter from the National Botanic Garden of Belgium. *Sterbeeckia* **30**: 38–50.

De Kesel A. & Gerstmans C. (2011) – Laboulbeniales (Ascomycetes). *Scripta Bot. Belg.* **47**: 171-180.

Dunn R. (2009) – Every living thing. Man's obsessive quest to catalog life, from nanobacteria to new monkeys. New York, HarperCollins.

Endersby J. (2008) – Imperial nature. Joseph Hooker and the practices of Victorian science. Chicago & London, The Univ. of Chicago Press.

Erwin T.L. (1982) – Tropical forests: their richness in Coleoptera and other arthropod species. *The Coleopterists Bulletin* **36 (1)**: 74-75.

Fraiture A. (2011) – Duchesnea indica, Fromeëlla mexicana, and associated organisms: a little ecosystem on a potentially invasive plant. *Scripta Bot. Belg.* **47**: 198.

Gonnet P.-H. (1847) – Flore élémentaire de la France. Première partie. Paris, J.-J. Ledoyen & P. Giret.

Gould S.J. (1996) – Dinosaur in a haystack. Reflections in natural history. London, Jonathan Cape.

Gribbin M. & Gribbin J. (2008) – Flower hunters. Oxford, Oxford Univ. Press.

Groom Q. (2011a) – Gall causing organisms. *Scripta Bot. Belg.* **47**: 155-158.

Groom Q. (2011b) – Observations on the occurrence of Cirsium ×hybridum in Belgium. *Scripta Bot. Belg.* **47**: 139-143.

Guiry M.D. (1997) – No stone unturned: Robert Lloyd Praeger and the major surveys. *In* J.W. Foster (ed.), Nature in Ireland. A scientific and cultural history: 299-307. Dublin, The Lilliput Press.

Hooker J.D. & Thomson T. (1855) – Flora Indica, vol. 1. London, W. Pamplin.

Hoste I. & Geerinck D. (2011) – The vegetation of the enclosed courtyard of the herbarium building. *Scripta Bot. Belg.* **47**: 145-153.

Jardine L. (2008) – Going Dutch. London, HarperCollins.

Koerner L. (1996) – Carl Linnaeus in his time and place. *In* Jardine N., Secord J.A. & Spary E.C. (eds.), Cultures of natural history: 145-162. Cambridge, Cambridge Univ. Press.

Koerner L. (1999) – Linnaeus: Nature and Nation. Cambridge & London, Harvard Univ. Press.

Lambinon J., Delvosalle L. & Duvigneaud J. (2004) – Nouvelle Flore de la Belgique, du Grand-Duché de Luxembourg, du Nord de la France et des Régions voisines. Cinquième édition. Meise, Jardin botanique national de Belgique.

McClain C. (2011) – The mass extinction of scientists who study species. *Wired Science*, January 19, 2011 [http://www.wired.com/wiredscience/2011/01/extinction-of-taxonomists/]

Noordijk J., Kleukers R.M.J.C., Van Nieukerken E.J. & Van Loon A.J. (red.) (2010) – De Nederlandse biodi-

versiteit. Nederlandse Fauna 10. Leiden, Nederlands Centrum voor Biodiversiteit Naturalis / E.I.S.-Nederland.

Pavord A. (2005) – The naming of names. The search for order in the world of plants. London, Bloomsbury.

Praeger R.L. (1937) – The way that I went. An Irishman in Ireland. Dublin/London, Hodges, Figgis & Co./ Methuan & Co. [1980 edition: Allen Figgis & Co.]

Ronse A. (2011a) – The wild flora of the Botanic Garden: an introduction. *Scripta Bot. Belg.* **47**: 27-58.

Ronse A. (2011b) – The 'truly' indigenous flora. *Scripta Bot. Belg.* **47**: 59-66.

Ronse A. (2011c) – Stinsen plants and other deliberate introductions in the (semi-) natural zones of the Botanic Garden. *Scripta Bot. Belg.* **47**: 67-75.

Ronse A. (2011d) – External neophytes. *Scripta Bot. Belg.* **47**: 77-88.

Ronse A. (2011e) – 'Botanic garden escapes' from the living collections at the Botanic Garden. *Scripta Bot. Belg.* **47**: 89-111.

Ronse A. & Leten M. (2011) – Wood lawn neophytes: historical park relics. *Scripta Bot. Belg.* **47**: 113-121.

Smit J.T. & Reemer M. (2009) – De soortenlijst van het Naturalis-terrein. *E.I.S. Nieuwsbrief* **48**: 16-28.

Smit J.T., Reemer M. & Kleukers R. (2009) – Zit er leven in Naturalis? 1569 soorten op 7 hectare stadsgrond. *E.I.S. Nieuwsbrief* **48**: 11-16.

Van de Kerckhove O. (2011) – Red List ectomycorrhizal fungi and their dependence on management. *Scripta Bot. Belg.* **47**: 181-191.

Van den Broeck D. & Ertz D. (2011) – A lichen hot spot at fifteen kilometres from the centre of Brussels. *Scripta Bot. Belg.* **47**: 159-170.

Van de Vijver B. & Compère P. (2011) – Aquatic diatoms (Bacillariophyta) from a small pool at the herbarium building. *Scripta Bot. Belg.* **47**: 199-205.

Walleyn R. & Vandeven E. (red.) (2006) – Standaardlijst van Basidiomycota en Myxomycota van Vlaanderen en het Brussels Gewest. Rapport INBO.R.2006.27. Brussel, INBO.

White P. & Langdon K. (2006) – The ATBI in the Smokies: an oveview. *The George Wright Forum* **23 (3)**: 18-25. [consulted at http://www.georgewright.org/233white.pdf, 02/11/2011]

Wilson E.O. (1988) – The current state of biological diversity. *In* Wilson E.O. (ed.), Biodiversity: 3-18. Washington D.C., National Academy Press.

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A short history of the land use and vegetation of the Botanic Garden

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Scripta Bot. Belg. **47**: I. Hoste (ed.), The spontaneous flora of the National Botanic Garden of Belgium (Domein van Bouchout, Meise)

Résumé. – Bref historique de l'utilisation des terres et de la végétation du Jardin botanique national. Le domaine actuel a été formé par l'assemblage des deux domaines féodaux de Bouchout et de Meise, qui datent respectivement du 10ième et du 11ième siècle. Il a été racheté en 1938 par l'Etat belge au roi Leopold II. L'utilisation historique des terrains au fil des siècles est commenté dans cet article. A partir de 1938 le domaine a été transformé pour l'aménagement du Jardin botanique dont les collections se trouvaient encore au centre de Bruxelles à ce moment-là. Des travaux de terrassement ont été effectués, et de nouveaux batiments, des serres et des collections de plein air ont été implantés. Pendant la guerre, il y a eu aussi beaucoup de perturbations, et le chateau de Meise a brûlé. Malgré tout, plusieurs zones sont restées plus ou moins intactes.

Samenvatting. – Een historisch overzicht van landgebruik en vegetatie van de Nationale Plantentuin. Het huidige domein is gevormd door samenvoeging van de twee kasteeldomeinen van Bouchout en van Meise, waarvan de geschiedenis teruggaat tot de 10de en de 11de eeuw respectievelijk. Het werd in 1938 door de Belgische Staat aangekocht van koning Leopold II. Het historische landgebruik doorheen de eeuwen wordt hier besproken. Vanaf 1938 werd het domein omgevormd voor de aanleg van de Plantentuin, die zich toen nog in het centrum van Brussel bevond. Er werd heel wat grond verzet, en nieuwe gebouwen, kassen en collecties in open lucht werden ingeplant. Ook tijdens de oorlog was er heel wat verstoring, en brandde het kasteel van Meise af. Toch bleven verschillende gebieden bewaard in min of meer ongerepte staat.

A botanical garden in the green belt around Brussels

The National Botanic Garden of Belgium is housed in a park that is called the Domain of Bouchout. The actual Domain is a fusion of the two feudal fiefs of Bouchout and Meise. King Leopold II purchased both domains for his sister Charlotte, Empress of Mexico. She came to live there as a widow until her death in 1927. In 1879 the castle of Bouchout, together with 171 ha of land, had been purchased from the family de Beaufort. Two years later this domain was enlarged by the acquisition of the neighbouring Hof van Meise, which until then had been the property of the family van der Linden d'Hoogvorst (Despodt 2001).

In 1938 the estate of the empress covered 293 ha, of which 82 ha was fenced and maintained as a park. The two castles were enclosed within this zone (Noppen 1991). The current Domain of Bouchout arose when the Belgian state bought the fenced grounds in 1938 together with a few more hectares along the southern perimeter (sectors 60, 61, 62, 63, 64, 65 and 66*). To-

* The Domain is divided into sectors, numbered from 10 to 71, see the map on page 26

day this entity, situated in the green belt around Brussels, comprises 92.7 ha. It was selected as the new location for the National Botanic Garden of Belgium when development plans for the capital and the construction of the North-South railroad connection prevented the institution from staying at its location in the centre of Brussels (Balis 1970, Anonymous 1970).

The Domain is situated in the hilly loam region of Brabant. According to the soil map (Louis 1961) about three quarters of the Domain consists of disturbed soils. Undisturbed soils can be found at the west side of the park. In the valleys alluvial soils on loam without profile development (Acp to Afp) occur, while on the higher plateau and hillside loam soils with texture B horizon (Aba) are present. The latter are well suited for agriculture due to their natural drainage and high soil fertility.

A streamlet called Amelvonnebeek (or sometimes Meise-Molenbeek) flows through the Domain from southwest to northeast. A little downstream it merges with the Maalbeek, a tributary to the river Zenne. A second streamlet, the Karlijbeek, enters the Domain in sector 25, close to the entrance next to the centre of Meise. Since the 19th century this small rivulet has been completely vaulted up to its confluence with the Amelvonnebeek which is close to the Sint-Anna chapel, in sector 18. Within the Domain lies a spring, in the so-called Machoechel area (sector 56), and a second spring is situated just outside the Domain, close to sector 43.

Before 1938

The history of the Domain of Bouchout can be traced back until the 10th century (Noppen 1991, Wauters 1972). The oldest part of the castle is the keep in Gobertanger sandstone, also called the square 'tower of Godfried with the Beard'. The keep dates back to the late 13th or early 14th century. Before this time, it is likely that the fortification was no more than a moat with a wooden tower.

As far as we know, the beginning of the fief Meise goes back to the 11th century. The oldest graphical source is an engraving by Harrewijn in a late 17th-century book (Le Roy 1699). It shows a baroque castle that has been transformed from an enclosed construction into a U-shaped estate, a construction typical for this period.

In 1818 this moated castle has been replaced with a neoclassical manor house, built by baron E. van der Linden d'Hoogvorst (Ganz 1987; Wauters 1972). In 1944 a bomb hit the castle and the ensuing fire destroyed it completely (Borremans & Swaerts 1989). The border between the two feudal domains of Bouchout and Hoogvorst was roughly constituted by the Amelvonnebeek, except in the centre of the Domain, where the sectors 14, 15, 16, 17 and 34 were included in the domain of Bouchout (Deneef &Vidts, in prep.). Today this streamlet divides the Botanic Garden in two parts.

The historic land use is summarised in figures 1 and 2. Sector 14 and part of sector 34, which were used as meadow, have been covered with sludge. For centuries, sludge from the moats around the castle of Bouchout (the later transformed into a small lake) was spread every year or every two years during Lent. Fish reared in the moats was an essential food source during Lent, when meat was banned. A thin layer of sludge from the moats was the perfect fertilizer for these meadows. This nutrient rich sludge has a very fine sediment structure, and this still characterizes the soil in this part of the Domain (Deneef & Vidts, in prep.). Until the 1950s, this zone was used as a meadow and was grazed by horses. Today it is still an open area with regularly mown grass that is grazed by naturalized geese.

The oldest traces of gardens around the two feudal castles can be found in their immediate surroundings. The laying out of these first gardens can be dated to the second half of the 17th century (Deneef & Vidts, in prep.). The island in the castle lake of Bouchout, today part of sector 13, is an example of such an early garden area. The area around the castle of Meise (part of sector 26) was also traced to the original garden. Nowadays it is an open park zone with both groups of trees and solitary trees dating back to the historical park. After centuries

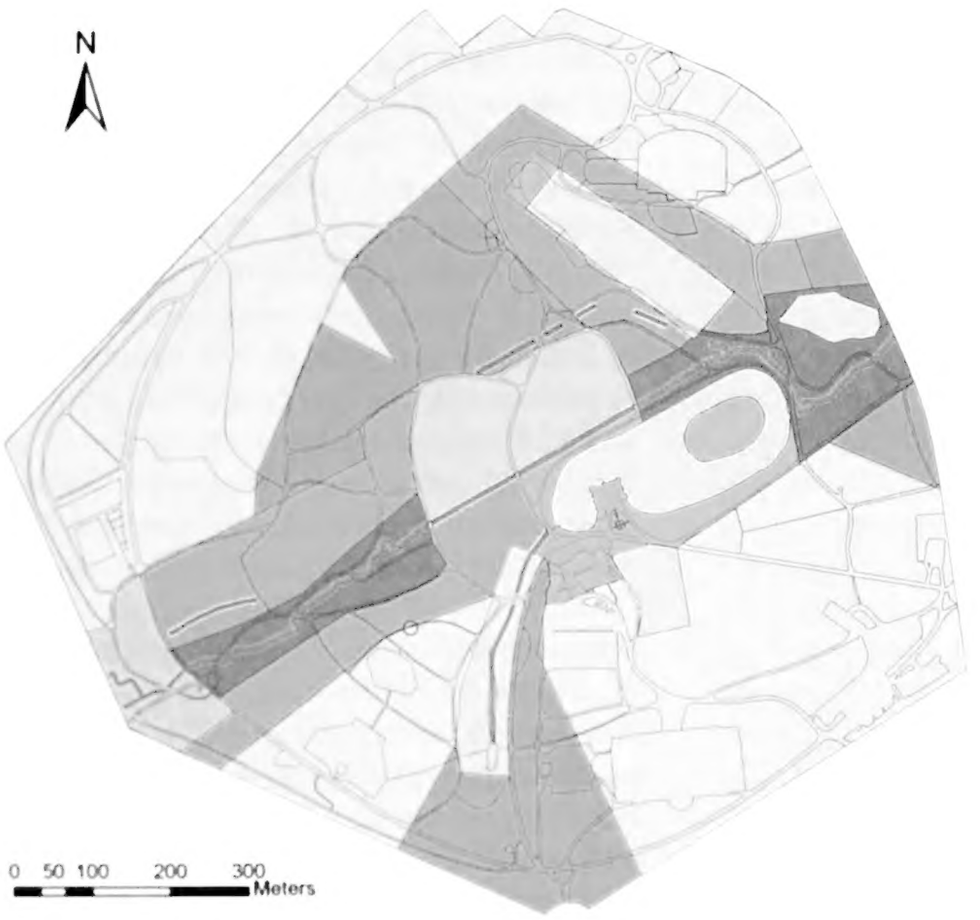

Figure 1. Historic land use of the Botanic Garden Domain before 1800.

- *arable land and orchards*
- *spring area*
- *coppice*
- *sludge meadow*
- *hay meadows and lawns*
- *frequently and thoroughly disturbed terrain*
- *forest park and historic woodland*
- *water and ponds*
- *stream*

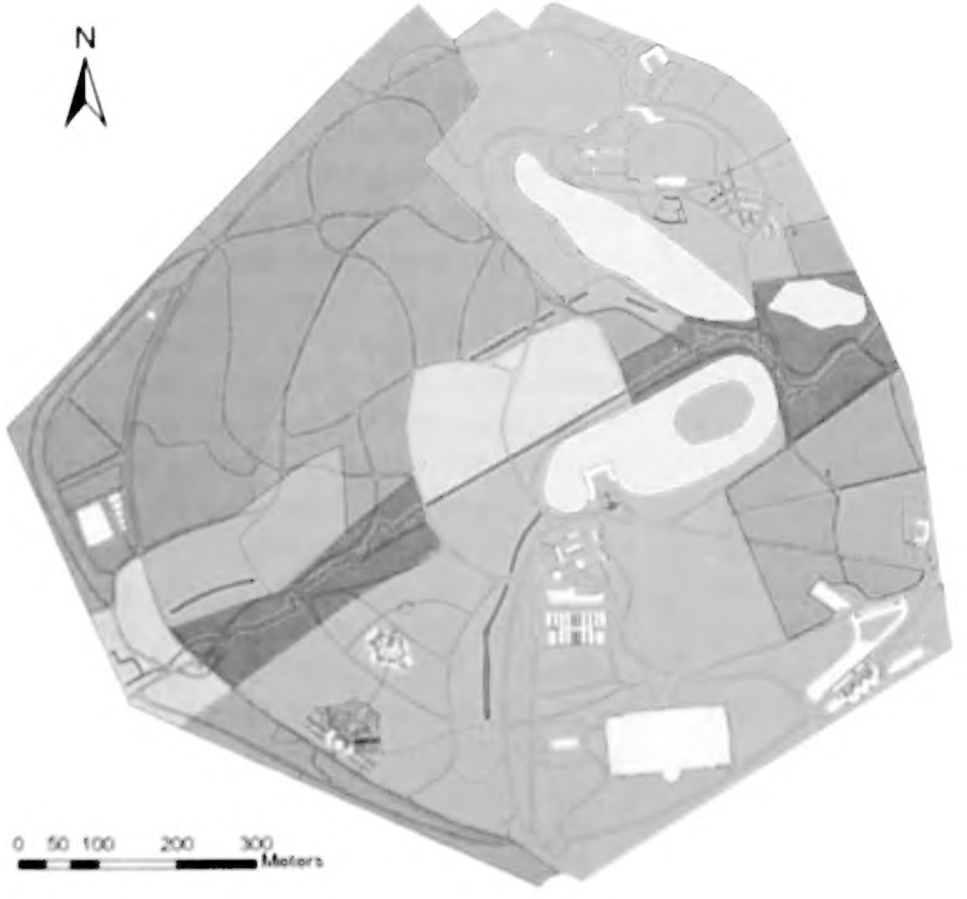

Figure 2. Historic land use of the Botanic Garden Domain in the 19th and 20th centuries.

- *undisturbed or moderately disturbed terrain*
- *spring area*
- *former coppice, today unmanaged*
- *historic sludge meadow*
- *hay meadows and lawns*
- *frequently and thoroughly disturbed terrain*
- *forest park and historic woodland*
- *water and ponds*
- *stream*

of cultivation, these areas are now characterized by disturbed and nutrient rich soils.

Until the early 19th century both castles were surrounded by the sloping agricultural landscape of the Brabant loam region. This landscape was characterized by small agricultural allotments bordered by trees, small woodlands and thickets. This cultivation pattern has determined the landscape of the loam region for more than 1,000 years in a rather uniform way. It can be clearly seen on the topographical Ferraris map from around 1775. On the consecutive editions of the topographic maps originally published by the *Dépôt de la Guerre* (nowadays National Geographic Institute) one can track how this originally rural area was transformed into a park during the 19th century. The surrounding land was turned into residential quarters during the 20th century. In the Domain one of the relict lanes that previously characterized this rural landscape, has been assimilated and still exists today in the park structure (Deneef & Vidts, in prep.).

The feudal woods or historical game hunting grounds of the landlords were located in the vicinity of their feudal settlement (Tack *et al.* 1993). Unlike the actual situation in which they have no economical function, these woods were also managed for the production of wood. Such open woods were also present around Bouchout and Meise. At Bouchout the former hunting grounds were situated in what are now the sectors 55, 56, 57, 59 and 61. The once feudal wood of Meise matches today's sectors 29, 31, 32, and 33 (Deneef & Vidts, in prep.). On the Ferraris map and in the local books of maps of Meise and Wemmel (drawn up respectively in 1717 and 1725) these hunting grounds are well indicated. On the Ferraris map both woody areas are assigned as open woodland with an undergrowth of coppice. This kind of rather open forest management was common in Flanders and resulted in a varied spring flora (Tack *et al.* 1993).

Taking into account a recent census of woody species within the Botanic Garden, and furthermore based on information in the register of the book of maps of Meise from 1717, we can state that the wooded areas of the domain of Bouchout were constituted as described by de Pouderlee (1772). In his *Manuel de l'Arboriste et du Forestier Belgiques* de Pouderlee suggested trees such as *Quercus robur*, *Carpinus betulus*, *Fagus sylvatica*, *Ulmus glabra* and *Fraxinus excelsior* for planting lanes and forests. One of the most frequent trees in the Domain today is *Fagus sylvatica*. These trees are characterized by a straight long stem and represent a local type that is typical for Brabant. The long trunks without side branches are ideal for construction wood and for the production of furniture. This local type holds true from seed.

In the late 18th and early 19th century many *Castanea sativa* were planted, especially in the close vicinity of both castles. *Populus canescens* and *Populus alba* were planted in between, and were chopped once the main trees had sufficiently grown. *Alnus glutinosa*, *Carpinus betulus*, *Corylus avellana* and *Tilia ×europaea* were mainly planted as coppice. The historical coppices were situated in the alluvial area along the Amelvonnebeek (now sectors 14, 16, 17, 18, 34, 36, 43, 44, 45 and 46).

The coppices were managed rather intensively until the first quarter of the 20th century. This is corroborated by accounts on sales of coppice wood and dead wood in the archives of the Empress (Despodt 2001). The management consisted of cutting back regrowth every 5 to 8 years. Each year, in the autumn, pigs were let in to forage in search of nuts, acorns and other edible fruits. These formerly rather open woodlands have nowadays turned into rather closed woodland.

In the early 19th century the old rural landscape with lanes that surrounded both castles was thoroughly transformed by the laying out of two English gardens. The picturesque garden around the castle of Bouchout dates back to 1805. The designer is probably the French architect François Verly. For Meise we know with certainty that around 1818 François Verly designed the garden for the newly rebuilt castle (Duthoy 1972, Goetghebuer 1827).

At the end of the 19th century Leopold II took the initiative to transform the English gar-

dens into a single enclosed park in the romantic landscape style. This means that during the 19th century the Domain has twice been thoroughly transformed: the first period of change was when the English gardens were laid out, the second one when the gardens were transformed into a romantic park for the Empress. One can state that owing to these past activities only the western part of the Botanic Garden (sectors 27, 28, 37, 38, 39, 40, 41 and 42) contains more or less undisturbed soils. Until the 20th century this area was mainly used as agricultural land. During the consecutive transformations into gardens and park, the feudal woods were cut as well. Field work has shown that the biggest beech trees all have a stem circumference of about 400 cm; from this we can tentatively conclude that the old hunting forest was cut in 1818 when the English garden was planted.

During the 19th century a lot of exotic shrubs and trees were introduced. *Acer platanoides*, *Deutzia* spp., *Philadelphus coronarius*, *Ribes alpinum*, *Syringa vulgaris* and *Symphoricarpus albus* are nowadays completely naturalized in the Domain and regenerate spontaneously. All these species have been introduced together with the oldest park and ornamental trees. They are concentrated mainly in the core of both estates, close to the locations of the (former) castles.

Some remarkable old park trees planted during the 19th century, before the transfer of the Botanic Garden from Brussels to Meise, are still doing well today; they include *Aesculus ×carnea* '*Marginata*', *Alnus glutinosa* '*Laciniata*', *Fraxinus excelsior* '*Diversifolia*', several *Liriodendron tulipifera*, *Taxodium distichum*, *Thuja plicata*, *Tilia platyphyllos* '*Vitifolia*', and the tallest and biggest tree of the Domain, *Sequoiadendron giganteum* (Anonymous 1996, Van Dievoet 1907).

A map from 1945 commissioned by the National Botanic Garden shows the areas that were then wooded. These were the sectors 11, 12, 15-19, 31 -33, 35, 36, 43, 59 and 68, as well as nearly the complete perimeter of the Domain (including sectors 25, 27 and 41). There were furthermore groups of trees or woodland zones in the main part of area 44, in the southern part of the areas 14 and 29, the eastern part of area 54, and the eastern and southern part of area 26. Orchards were situated in sectors 10, 20 and 45.

After 1938: the new State Botanic Garden

When the Domain was purchased in 1938, the park had been neglected for a number of years. Before the Second World War the entrances and roads were restored, the park was tidied up, tons of dead leaves were removed and diseased or dead trees were felled (Balis 1970). In 1939 and 1940, the first specimens were transplanted from the living collections in Brussels to the new location in Meise; they can still be found in planting areas in the sectors 62, 63, 64 and 66.

During the Second World War the Domain was consecutively occupied by Belgian, German and American troops. This resulted in considerable damage to the park: trees were cut and undergrowth was destroyed, roads were shifted, the meadow at the northwestern boundary of the Domain was used by practicing equestrians, several lawns were ploughed for the cultivation of vegetables. Later on, the Domain was used as a firing range, and heavy trucks and tanks caused a lot of damage. During the war, however, some preparatory ground levelling work was conducted. These works still determined the arrangement of the collections in the Botanic Garden: the slope in sector 46, for instance, was levelled (Borremans & Swaerts 1989).

After the war several areas underwent drastic changes of relief. In 1957 the heating building (with its boilers) was erected, followed by the herbarium building in sectors 64 and 65 in 1959-1961; this building also includes the library and offices for management, administration and research departments. Intensive ground works, including levelling, took place in sectors 60 and 61 in order to prepare the erection of the Plant Palace (in 1956); this complex of greenhouses covers circa 1 ha and contains tender plants. In 1959-1960 the previous garden of Bouchout (areas 70 and 71) were flattened for the construction of the nursery

greenhouses, and near the old homestead an office building was erected. Since the middle of the 20th century all excavations were done mechanically, locally causing serious compaction of the soil that is still noticeable today.

Many collections have been planted during the past decades. In the seventies, the herbetum (1976, for herbaceous plants), the fruticetum (1978, for shrubs and trees) and the coniferetum (1941, 1978) were planted in the area that had been levelled during the war. Thematic collections were created in scattered locations within the park, such as the collections of *Acer*, *Quercus*, *Rhododendron* and *Hydrangea*. The historical walled garden, to the north of the orangery, houses living collections of *Iris*, *Sempervivum*, and some other genera.

After the war the damaged roads were reconstructed and the ruins of the burned castle of Meise were torn down (1949). The waste materials were used as foundation for the roads, and the Gobertanger sandstone from the plinth was used to retain the walls of the raised flower beds that surround the terrace of the orangery. The lake (sector 21) was extended at its northern edge. The three lakes of the Domain were emptied and their banks strengthened with reinforced concrete slabs. Thousands of cubic metres of sludge were deposited in the western part of sector 46 (now the fruticetum) and in sector 34 (the former 'sludge meadow'). In parts of the sectors 44 and 45 there used to be another lake called Pike pond or 'de Bilt', but it has been filled up with dredging sludge from the other lakes. The rivulet that flowed through this long pond – starting at the spring near the mill of Amelgem – was deflected into the Amelvonnebeek. In the central part of the Domain the course of the latter streamlet was straightened. The Karlijbeek, a streamlet that enters the Domain from the north, was completely covered and its bed shifted. The marshy area in the western part of sector 26, where it had its course, was levelled. On several locations in the Domain drainpipes were laid, for example in the woody parts of sector 44.

In 1967 the sectors 43, 44 and 45 were assigned as natural areas, then called 'heemtuin'. The waste that had been dumped in sector 44 next to the actual ring road was removed and was used for the construction of the kidney-shaped slope in sector 55. In the middle of the valley a new rivulet was dug at the level of the former Pike pond. The stinging nettles (*Urtica dioica*) that grew man-high in this area were mown and manually removed year to year in an effort to reduce their numbers. Several decades of intensive management have indeed resulted in a relatively impoverished soil, gradually transforming the area into a valuable (semi-) natural vegetation.

In 2006 a differentiated mowing management regime of the grasslands was introduced in the Domain (Ausloos 2006), putting an end to a regime that had been applied since 1963. Before 1963 the lawns had been grazed by horses or maintained as hay meadows. After that year all lawns – except for the 'heemtuin' and the Machoechel – were mown weekly during the growing season, and all the dicot weeds in the lawns were controlled with herbicides (until 1986). Moreover, until 1981 fertilizers were used. Since 2006, different types of lawns are distinguished, namely utility lawns, natural lawns, landscape lawns and woodland lawns. Each type has its particular mowing height, frequency, and period (Ronse 2011a). Moreover, some grassland is not mown before the 15th of July. This kind of management is for example applied in 'de Bilt' (sector 44 and 45), in the Machoechel (sector 56 and 57), and locally around the castle (sector 13). The results of this new and diversified approach have been positive: since 2008 the massive flowering of ox-eye daisies (*Leucanthemum vulgare*) is a striking feature in several areas around the castle lake. The forest management too has recently been adjusted: in some areas the fallen leaves of trees are systematically removed in order to promote the growth of rare mushrooms, including several Red List species of the genus *Boletus*.

The Domain as it is now

The Domain is a historically valuable park, in which management emphasises natural developments in a number of carefully selected ar-

eas. Within the park the following types of land use are present: (ancient) woodland, grassland (short-cut or not), lanes and lakes, intensively managed living plant collections, nurseries and flowerbeds (part of these tended in greenhouses), and finally historical as well as more recent buildings that house the infrastructure of the National Botanic Garden of Belgium. In terms of management this means that some parts of the Domain have a more or less natural, minimally disturbed vegetation, whereas other parts – in particular those with the botanical collections – are characterized by an intensive management.

There have been numerous interferences in the Domain throughout history and only a few parts have been left untouched in the past few centuries. At the beginning of the 19th century parts of the feudal woods were cut and the castle estates were laid out in a picturesque style. During the Second World War considerable damage, including soil compaction, was inflicted due to ground works and various military activities. Finally, some drastic changes have accompanied the transformation of the former private park into a public garden that also houses a scientific institution.

The result of all these changes is that the southern part of the Domain has been thoroughly dug up, and that soils have been severely compacted. This is the area where the main part of the collections have been planted. Only the immediate surroundings of the Machoechel have been well-preserved. The northern part of the Domain has also been thoroughly transformed after the burning of the castle d'Hoogvorst in Meise (in 1944), and for the construction of the collections. Areas that underwent less significant transformations are situated in the central and eastern part of the Domain, around the castle of Bouchout and around the three lakes.

From figure 2 we may conclude that only the sectors 18, 31, 32 and 33, and parts of the sectors 36, 44 and 45 have kept their original function as woodland or moist coppice wood. The trees and shrubs growing in these areas, are the same that were already cited by de Pouderlee in 1772. Nowadays some old coppice stools of lime (*Tilia* spp.) and hornbeam (*Carpinus betulus*) have grown into multi-trunked trees. Moreover, the sectors 14 and 34 are still used as open grassland. Finally, sector 43 is a little-disturbed moist well area with calcareous seepage (resulting in the formation of tufa) and a vegetation of alder-ash-woodland (*Carici remotae-Fraxinetum*) (see also Ronse 2011b).

The oldest and biggest trees of the Domain grow at the western edge of the former castle estate of Meise, in the sectors 28, 31 and 38. These monumental specimens of pedunculate oak (*Quercus robur*) and sweet chestnut (*Castanea sativa*) probably date back to the first half of the 18th century. They have a stem circumference of more than 5 metres. This area has also been used as agricultural land for the longest period.

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Sources

Literature

Anonymous (1970) – De Nationale Plantentuin van België 1870-1970. Brussel, Nationale Plantentuin van België.

Anonymous (1996) – Korte geschiedenis van het domein van Bouchout. Meise, Nationale Plantentuin van België.

Ausloos G. (2006) – Graslanden in de Plantentuin en hun beheer. *In* Tuinierscursus. Deel II : werken met planten: 1-10. Meise, Nationale Plantentuin van België.

Balis J. (1970) – Geschiedenis van de Brusselse plantentuinen. Brussel, Gemeentekrediet van België.

Borremans P. & Swaerts D. (1989) – Het Domein van Bouchout. Van kasteelpark tot plantentuin, 1939-1989. Meise, Nationale Plantentuin van België.

Deneef R. & Vidts S. (in prep.) – Historische tuinen en parken van Vlaanderen, cahier 20. Brussel, Vlaamse Overheid, Agentschap R-O Vlaanderen, Onroerend Erfgoed.

de Pouderlee (1772) – Manuel de l'Arboriste et du Forestier Belgiques. Bruxelles, J.L. de Boubers.

Despodt V. (2001) – Inventaris van het Archief van het Huis van Keizerin Charlotte in België (1867-1927). Onuitgegeven verhandeling tot het bekomen van de graad van gediplomeerde in de Archivistiek, Academiejaar 2000-2001. Brussel, V.U.B.

Duthoy J.-J. (1972) – Un architecte Néo-Classique: F. Verly. *Revue Belge d'architecture et d'histoire de l'art* **41**: 119-149.

Ganz E. (1987) – Het koninklijk domein van Bouchout en

zijn kastelen. Brussel, Ets. Jean Melvaux N.V.

Goetghebuer P.J. (1827) – Choix des monuments, édifices et maison les plus remarquables du royaume des Pays-Bas. Gent, A.B. Stéven.

Le Roy J.-J. (1699) – Castella & praetoria nobilium Brabantiae coenobiaque celebriora. Leyden, Petrus vander Aa.

Louis A. (1961) – Bodemkaart van België. Verklarende tekst bij het kaartblad Vilvoorde 73W. Leuven, Centrum voor Bodemkartering.

Noppen C. (1991) – De Heren van Bouchout en hun Waterburcht te Meise. Brussel, Drukkerij Poot N.V.

Ronse A. (2011a) – The wild flora of the Botanic Garden : an introduction. *Scripta Bot. Belg.* **47**: 27-58.

Ronse A. (2011b) – The 'truly' indigenous flora. *Scripta Bot. Belg.* **47**: 59-66.

Tack G., Van den Bremt P. & Hermy M. (1993) – Bossen van Vlaanderen, een historische ecologie. Leuven, Uitgeverij Davidsfonds.

Van Dievoet H. (1907) – Les beaux conifères de Belgique et leur culture / Les grands arbres de la Belgique / Les jardiniers en maison. *La Tribune Horticole* **2**: 234 / 370-371 / 611-614.

Wauters A. (1972) – Histoire des environs de Bruxelles, ou description historique des localités qui formaient autrefois l'ammanie de cette ville. Nouvelle edition du texte original de 1855. Vol.5. Bruxelles, Culture et civilisation.

Maps

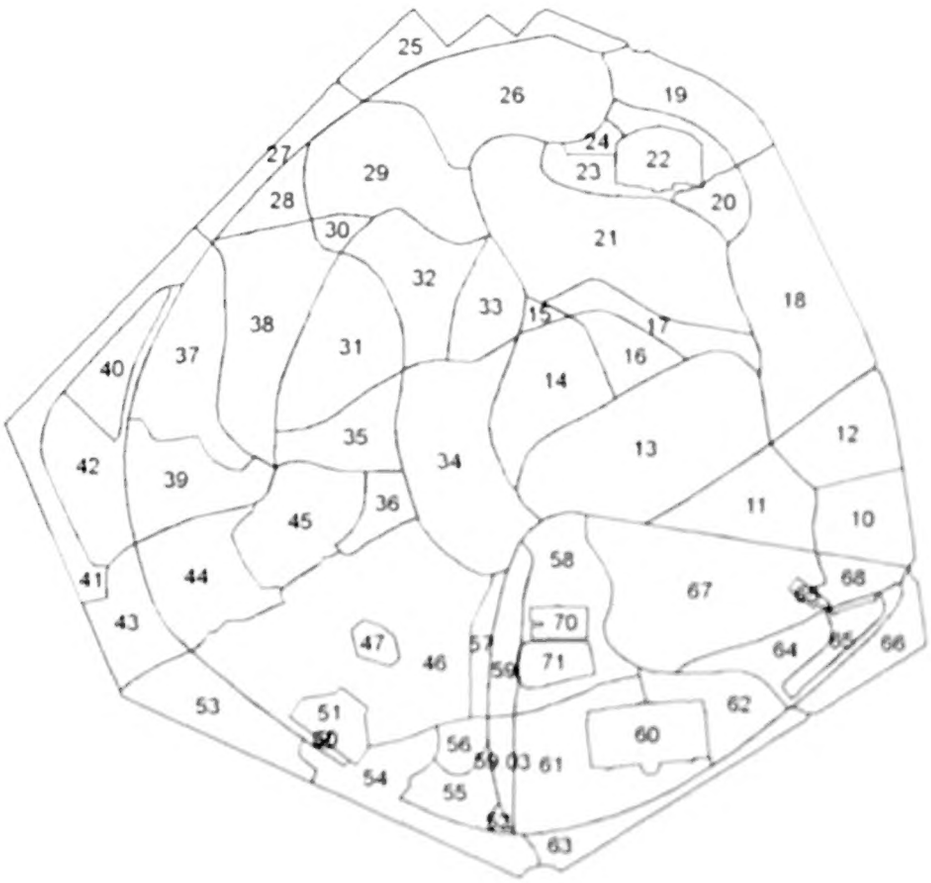
Carte de Cabinet des Pays-Bas Autrichiens. Levée à l'initiative du comte de Ferraris. Blad 75: Vilvoorde. Reproductie uitgegeven door Pro Civitate (Brussel, 1965).

Carte topographique de la Belgique. Feuille 23/7. Bruxelles, Dépôt de la Guerre, editions 1865 and 1909.

Plan parcellaire de la commune de Meysse: avec les mutations jusqu'en 1837 + Tableau indicatif des propriétaires de la commune de Meysse. Bruxelles, Ets. Ph. Vandermaelen, ca. 1838.

The local books of maps of Meise and Wemmel, drawn up in respectively 1717 and 1725.

Annex. Map of the Domain of the National Botanic Garden of Belgium with location of the sectors.



Scripta Botanica Belgica **47**: 27-58 (2011)

The wild flora of the Botanic Garden: an introduction

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Résumé. – La flore spontanée du Jardin botanique: une introduction. Plusieurs motifs d'ordre pratique et d'ordre scientifique ont donné lieu à la réalisation d'une étude de la flore (sub)spontanée du Domaine. Dans cet article, les méthodes et définitions utilisées sont expliquées, ainsi que l'application de six catégories de plantes, qui a par ailleurs déterminé la structure des textes ultérieurs dans ce volume concernant les plantes vasculaires. Ensuite un aperçu de la biodiversité végétale du Domaine est donné, utilisant plusieurs caractères comme le nombre, le degré de rareté et le caractère indigène des espèces. Ces données sont associées à l'utilisation et à la gestion des terrains.

Samenvatting. – De spontane flora van het Domein: een inleiding. Verschillende redenen van zowel praktische als wetenschappelijke aard hebben geleid tot het opstellen van een studie van de spontane flora van het Domein. In deze bijdrage worden de gebruikte methodes en definities toegelicht, evenals de indeling van de plantensoorten in zes categorieën, die de structuur van de verdere bijdragen over hogere planten in dit volume bepaald hebben. Vervolgens wordt een overzicht gegeven van de biodiversiteit aan de hand van bepaalde parameters, o.a. het aantal soorten, hun zeldzaamheid en hun al dan niet inheems karakter. Deze gegevens worden ook in verband gebracht met het landgebruik en beheer.

Why study the flora of the Domain of the Botanical Garden?

Only a small part of the natural vegetation of the Domain has been previously recorded. The 'Biologische Waarderingskaart' (Desaeger *et al.* 2000) indicates that the main part of the castle estate of Meise is a complex of biologically valuable and biologically very valuable elements; it also lists some special plant species, but doesn't give detailed locations of their occurrences. Moreover, some records made by staff members are present in the database of living collections (LIVCOL), though it mainly contains records of cultivated plants. A third source of data is the survey of spring flowers made by Van Mello (2001) in part of the Domain in one year, but a systematic inventory was never conducted.

The lack of information on the natural vegetation has lead us to start this study, since a detailed knowledge of the vegetation and of the species growing in the Domain would yield many benefits. First of all, a thorough knowledge of the plant species is crucial for a good management. The actual and the potential natural value of the different areas is an important factor in choosing their management. With knowledge of rare and valuable plant species management can be adapted to encourage them if it is desired. On the other hand, the knowledge of the (potentially) invasive exotic species in the Domain is of interest, in order to plan their control. "A complete and detailed inventory is necessary for the management of the collections as well as for the management of the park", as the manager of the outside collections of the National Botanic Garden wrote

in an internal note on the development prospects of these collections (De Meyere 1998). He asked urgently for a survey of the (herbaceous) vegetation. The thorough knowledge of the plant species and vegetation present in the Domain is not only a necessity for management decisions but also for the evaluation of the management. By recording the presence of species and their abundance, the health and succession of vegetation can be monitored. It is unfortunate, that this had not been done until now. For example, in 2006 different mowing regimes where implemented for the lawns, in order to increase their natural value (Ausloos 2006), but their original condition was not recorded systematically at that time.

The floristic study of the Domain is also important for building policy. The conservation value of these sectors should be taken into consideration, for example when planning new buildings or other infrastructure. Highly valuable natural areas should be spared as much as possible. The conservation value of an area is partly determined by the presence of animal species and other organisms. However, as their presence is often linked to the vegetation, the vegetation is regarded as the most important variable (Klijn & the Haes 1990). In 2008 a geographical masterplan of the Domain of the Botanic Garden was drawn. Vanhecke (2008) wrote a document about the ecological value of the sectors of the Domain, to be used as a basis for the development of this masterplan. As the author stated "the lack of any ecological approach during the consultations for the Masterplan had led to a questionable allocation of some sectors". In order to fill this gap, Vanhecke put together all data related to the ecology of the Domain known at that time, among other the then available vegetational data recorded for this study.

So far, the justifications for the study have concerned the better management of the park. There are, however, also good scientific reasons to survey the wild flora of the park. This paper aims primarily to describe the biodiversity of vascular plants within the Domain, mainly as the number of species and their identity, and, if possible, to relate it to the current and historical management and land use. The importance of information on biodiversity is amply demonstrated in many books and articles, so this will not further be elaborated here.

Botanical gardens are also interesting places to study the behaviour of exotic plant species. In the nineteenth century Devos (1870a) regarded botanic gardens as naturalization centres for plants, where cultivated species escape from the collections, and spread within the gardens at first, while some of them manage to escape outside the gardens. That's why this author finds it of uttermost importance that botanical gardens should make lists of internally naturalizing species. Indeed, in our flora several more or less common exotic species can be found that have spread from botanical gardens. An example of such a neophyte is *Impatiens parviflora*, a species that escaped from European botanic gardens in the 19th century. Another example is *Veronica peregrina*, nowadays a rather common species in Flanders, after having had an explosive expansion. It began its spread in Europe near the botanic garden of Montpellier (France), where it had already naturalized in the 17th century (Devos 1870b).

Five categories of vascular plants

The results of our study of the wild vascular plant flora of the Domain of the National Botanic Garden of Belgium are rendered in several contributions to this volume of *Scripta Botanica Belgica*. In this contribution a short description is given of the methods. After this, the criteria are discussed for the classification of the plant species in categories. Then an overview is given of the biodiversity of the wild flora, namely the total number of species; the proportion of species within each category; the number of species per sector; the indigenous character of the vegetation and the rarity of the species; the occurrence of old forest species and of acidophilic species. In another part of the text all these biodiversity parameters are related to the historical and current management and land use. The historical data on land use can be found in Ronse & Vidts (2011).

A more detailed discussion of the vascular

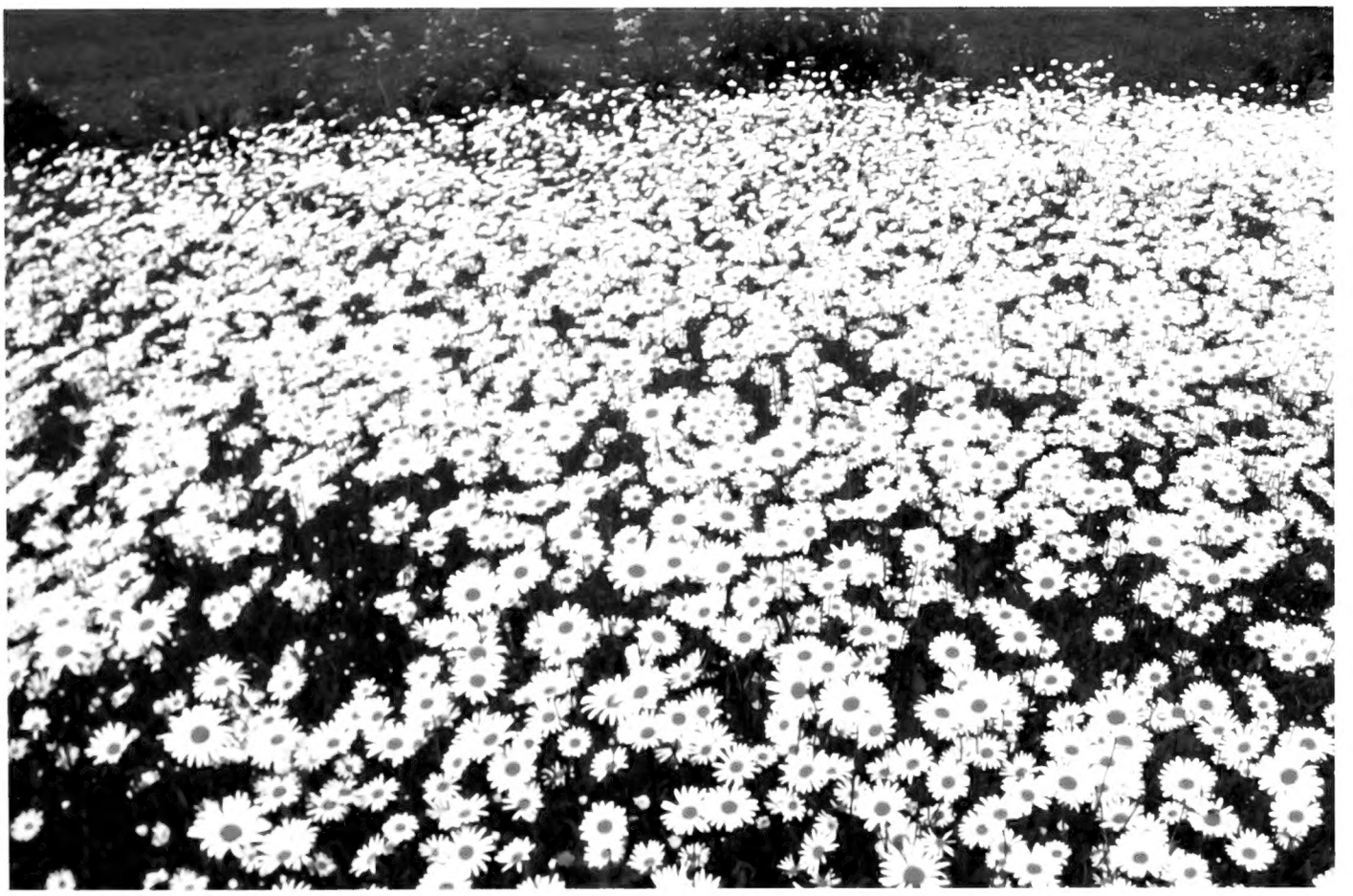

Figure 1 Leucanthemum vulgare *in sector 13. (Photo A. Ronse)*

Figure 2 Acronycta hibisci *in 1985 in sector 64. (Photo L. Landuyt)*

plants of the Domain per category is presented in further contributions to this volume. First the species are treated per category in separate contributions per category, except for category 4 and 6, that are treated together. After this, several short articles by different authors are given about particular species. This is the overview of the contributions per category:

- Category 1: the 'truly' indigenous flora of the Domain of the National Botanic Garden of Belgium (Ronse 2011a). (Fig. 1)
- Category 2: External neophytes in the Domain of the National Botanic Garden of Belgium (Ronse 2011b). (Fig. 2)
- Category 3: botanic garden escapes (Ronse 2011c). (Fig. 3)
- Categories 4 and 6: 'Stinsen plants' and other deliberate introductions in the (semi-) natural sectors of the Domain of the Botanic Garden (Ronse 2011d). (Fig. 4)
- Category 5: wood lawn neophytes: historical park relics (Ronse & Leten 2011).

Methodology

The data on the wild vascular flora of the Domain presented in this volume have been gathered mainly by the author. From 2002 to 2010 I have made lists of the wild plants in the Domain of the National Botanic Garden in Meise. This comprises both 'truly indigenous' species and other spontaneously occurring species, as well as naturalized species. In the grasslands and woodlands all species were noted. In the collections and nurseries all plants that grow outside their original plant beds were included. Initially garden escapes were only noted when they were outside the collections, but in a second step they were also listed if further than 3 m away from their plant beds.

A plant list was made of each sector. **Sectors** are areas of different size within the Domain, as defined and numbered for management (see the map in appendix 1). The sectors are often demarcated by roads. While gathering the data I have tried to pay at least two visits to each sector in different seasons. All sectors of the Domain were visited, except the buildings and the greenhouses. The weeds that grow in the greenhouses are mostly tropical species that cannot survive and spread in the open in our climate, so they were not noted in this study. Some observations originate from a non-heated greenhouse and some from plants that overwinter in an Orangery. In total 54 sectors were inventoried; their numbering starts with 10 and ends at 71.

In order to complement these data, the observations on spring flowers made in 2001 by Van Mello were used. I also received additional observations from several colleagues (see acknowledgements). Some data from floristic lists and from the herbarium were received from Florabank, the databank with floristic data of the vascular plants in Flanders (http://flora.inbo.be//Pages/Common/Default.aspx). Statistical analyses were made with the software program SYSTAT (version 8.0).

Definition of categories

Several criteria were used in order to distinguish the different categories of plants growing in the Domain. The first one is whether the species is originally indigenous to the area. The definition and practical application of the word indigenous has been discussed many times. In this text I have chosen the pragmatic solution of following the definition that is used in the *Catalogue of neophytes in Belgium* (Verloove 2006). In this view, archaeophytes are considered to be indigenous, unless they were introduced again recently. For the classification of species into categories this catalogue has been used as a base, as well as the *Nouvelle Flore de la Belgique, du Grand-Duché de Luxembourg, du Nord de la France et des Régions voisines* (Lambinon *et al.* 2004) and the Flemish plant atlas (Van Landuyt *et al.* 2006).

Among the indigenous species a distinction can be made whether the plants are from local indigenous source or not. Indeed, during this study questions arose about the indigenous character of some plants. Initially, the aim of this study was to make inventories of the wild species in the Domain, but gradually it became clear that there is a vast grey zone between the 'truly wild' plant populations and plants that

Figure 3. Inula helenium *in sector 13. (Photo A. Ronse)*

Figure 4. Lathraea clandestina *in sector 48. (Photo P. Borremans)*

have escaped from the collections. I have repeatedly found specimens of rare indigenous species that have probably originated from cultivated plants. Many indigenous species are grown in the outdoor collections, including rare species. Most of them are well adapted to our climate, so they can spread easily outside their flower bed, sometimes over a long distance. This has forced me to entertain some doubts regarding the indigenous character and the origin of each species. Similar observations have been made by Cope (2009), who has written a book on the wild flora of the Royal Botanical Gardens at Kew (Great Britain). He also describes his doubt about the origin of seemingly indigenous plants. The situation at Meise is, however, less extreme than at Kew, where 95% of the indigenous flora has been cultivated in the gardens since the origin of the gardens. At Meise this proportion is probably much lower, as the estate has only been used as a botanic garden since 1939, a much shorter period than at Kew. However, we have no data on the exact number of indigenous species that have been grown in the collections.

The geographic origin of the indigenous species that are grown in the Botanic Garden often lies outside the region or even abroad. This should be taken into account, as the genetic origin of plants also is an important aspect of biodiversity. In nature conservation, plant material from local origin is valued more than material from other regions or countries. The occurrence of rare plants from foreign origin is also thought of as less valuable than of 'truly indigenous' plants. That is why the origin of the non-cultivated plants in the Domain has been examined as much as possible. Only the plants of local origin are considered to be 'truly indigenous' in the Domain.

A third criterion is whether the plants in the Domain have spread or multiplied from plants in the collections. This criterion cannot always be unequivocally determined, but can mostly be retrieved by consultation of historical sources. Every species was looked up in the digitalized accession catalogue of the Botanic Garden LIVCOL, to find out if the species is or has been cultivated somewhere in the Domain. However, this catalogue only contains data of plant origins since 1990. It was not feasible to consult the non-digitalized, older data in the scope of this study, but this is planned for further study.

A fourth criterion that is used to classify the species in categories is whether they have been introduced on purpose in parts of the Domain outside the collections. This is the case for 'stinsen' plants, species that have been planted in the Domain when it was a castle estate, before it became a botanic garden. There are also examples of indigenous species that have been introduced in (semi-) natural areas outside the collections, after the founding of the Botanic Garden. These four criteria have led to the classification shown in Table 1.

Three remarks can be made here. The six categories don't consist of unique combinations of the criteria. Both category 3 and 6 possess more than one combination of criteria, and they could be further subdivided. A second remark concerns the fact that it is not always possible to ascertain to which category a plant belongs.The plants have been classi-

Table 1. Categories of plants within the Domain, with reference to the pages in this *Scripta* where they are treated in detail.

Category	Name	Indigenous species	Local origin	Escaped from collections	Deliberate introduction
1 (p. 59)	'Truly' indigenous plants	+	+	-	-
2 (p. 77)	External neophytes	-	-	-	-
3 (p. 89)	Botanic garden escapes	+/-	+/-	+	-
4 (p. 67)	Stinsen plants	-	-	-	+
5 (p. 113)	Wood lawn neophytes	-	-	-	-
6 (p. 67)	Indigenous introductions	+	+/-	-	+

fied according to the available knowledge. The third remark is that a species can belong to more than one category; namely when there are plants of this species in the Domain with different origins. This can be illustrated by the case of *Asplenium scolopendrium*, an indigenous fern that grows in natural habitats outside the Botanic Garden but close to it, mostly on river banks. This species occurs in two locations on the Domain in similar conditions, but also on the stones of a gate, where they have been planted. There are also plants on a fourth location where they have been planted as 'stinsen' plants before the founding of the Botanic Garden. This means that this species has plants that are representative of categories 1, 4 and 6.

• **Category 1** consists of locally indigenous species from local source that have not escaped from the collections and that have not been planted. They can be called '**truly indigenous species**', the species that were probably already present in the Domain before the eighteenth century, before the founding of the Botanic Garden and before the laying out of gardens in the English style. See also the remark under category 4. These species are discussed by Ronse (2011a).

• **Category 2** are non-indigenous (exotic) species that have not escaped from the collections and that have not been deliberately introduced. They are called here **external neophytes**. They are mostly exotic species that can also be found in the area around Meise (Ronse 2011b).

• **Category 3** are the so-called **collection escapes**, these are plants that have propagated from the collections. As is apparent from table 1, they can be either indigenous or non-indigenous species. The main criterion is that they originate from cultivated plants. In order to determine whether this is the case, two factors were investigated: first the actual or past presence of the species in the Garden's collection, and second the distance between the observed plants and the (formerly or currently) cultivated plants in the collections. The collection escapes are discussed by Ronse (2011c).

• **Category 4** concerns deliberate introductions of non-indigenous species in the (semi) natural parts of the Domain, the so-called '**stinsen plants**' (Ronse 2011d). The definition of Bakker & Boeve (1985) is followed here, namely species that have deliberately been planted and are naturalized in a region where these plants don't occur naturally. Most of the time they are species or varieties with striking flowers and with highly decorative value, and these species have mostly been planted in the eighteenth or nineteenth century. This definition is strongly dependent on the area, this means that the interpretation whether a species is a stinsen plant or not depends on the geographical position of the area. Part of the forest flora of the Domain (such as *Allium ursinum*, *Arum maculatum* and *Anemone nemorosa*) is probably truly indigenous, even if some of these species are known as stinsen plants in Friesland and some other parts of The Netherlands. Sometimes indigenous species can also be planted in a park or estate, but after some time this becomes impossible to trace. So these plants are classified as truly indigenous (category 1).

• **Category 5** consists of locally non-indigenous species that have been introduced unintentionally by man. They could be placed in category 2 (external neophytes), since they are non-indigenous plants that have not escaped from the collections and have not been introduced deliberately. However, they have been classified separately because they have been introduced in a very specific manner, namely in seed mixtures for 'wood lawns'. They are (mostly grasslike) plants that have been sown when the English gardens were laid out. The lawn seed mixtures also contained seeds of other grasses, sedges and rushes as impurity. Some of these species have survived in old parks and estates and have been called, in German, *Grassameneinkömmlinge*, which could be translated as '**wood lawn neophytes**'. More information on these species can be found in Ronse & Leten (2011).

• **Category 6** consists of **indigenous plants** from non-local sources that have been **deliberately introduced** to (semi-) natural parts of the Domain, thus outside the collections. This definition resembles that of category 4, the 'stin-

sen plants', but they concern indigenous species. Moreover, they have been introduced in a later period, when the Botanic Garden was laid out in the Domain. However, because of their similarity with this category, they are treated here together in one contribution. Perhaps indigenous species from non-local source have also been introduced into the Domain before the founding of the Botanic Garden, but there are no records of that.

Results: an overview of the biodiversity of vascular plants

Number of species

Between 2002 and 2010 in total 586 species of vascular plants have been found (appendix 1). Sixty percent of these are truly indigenous species, 27 % are considered to be garden escapes, 7 % are external neophytes, 4 % are deliberate introductions and 'stinsen plants' and 1 % belong to the category of *wood lawn neophytes*. These percentages don't say anything about the relative frequency of the categories, since some species occur more frequently than others in the Domain.

The numbers of species per sector lie between 19 and 190, with an average number of species per sector of 98. The geographical distribution of the numbers per sector is shown in figure 5. There are fourteen sectors with more than 120 species. These sectors lie mainly in the eastern half of the Domain and there is also a concentration in the northwestern part. The sector with the highest number of species is located around the castle of Bouchout (sector 13); 190 species were observed there. This sector consists of both woodland and grassland, of which parts are mown as natural grassland since 2006 (see further under grassland management). The second highest number of species per sector has been found in sector 43, where the stream Amelvonnebeek enters the Domain. This sector consists of fen valley wood, and is a relatively undisturbed area, where 163 species have been recorded. The third most rich area is the neighbouring sector 44 with 159 species, and in fourth place is sector 18 with 158 species, a sector with wood-

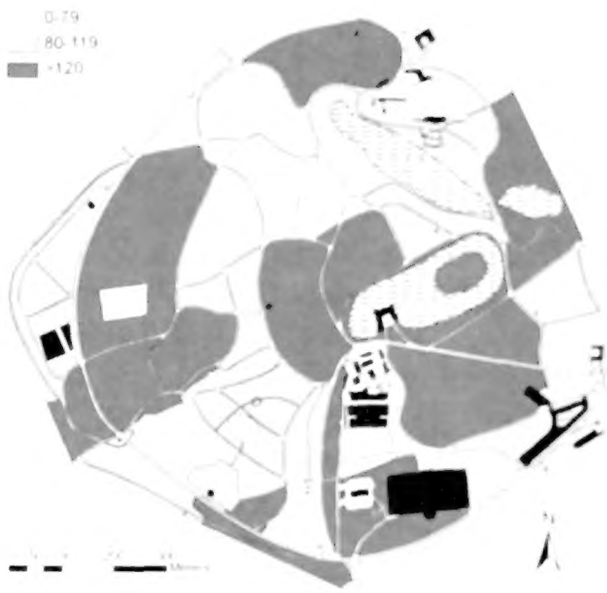

Figure 5. The geographical distribution of the species numbers per sector.

land that is situated at the other side of the Domain, on the place where the stream leaves the Domain. These sectors along the Amelvonnebeek correspond partly to the area that was historically managed as coppice wood (Ronse & Vidts 2011).

There are twenty four sectors with between 80 and 120 species, lying more or less evenly distributed within the Domain. The sixteen sectors with less than 80 species lie mainly in the north of the Domain.

The number of species found in each sector is determined in part by its area. When we calculate the number of species found per 1000 m² in each sector of the Domain, we obtain a number of between 2 and 43 species per 1000 m², with an average number of 12. The relation between area and number of species is not linear, but logarithmic, so there is a stronger increase at low values. This can be seen in figure 6, showing the number of species per sector in relation to the surface area of each sector (in m²), and where each sector is labeled with its number. The resulting curve has been obtained by 'best fit' based on a logaritmic model, that is the theoretical curve type for this kind of relationship, even if it does not show a very high fit here.

This figure shows which sectors have a higher than average species richness, as they lie above the fitted line. These are mainly sec-

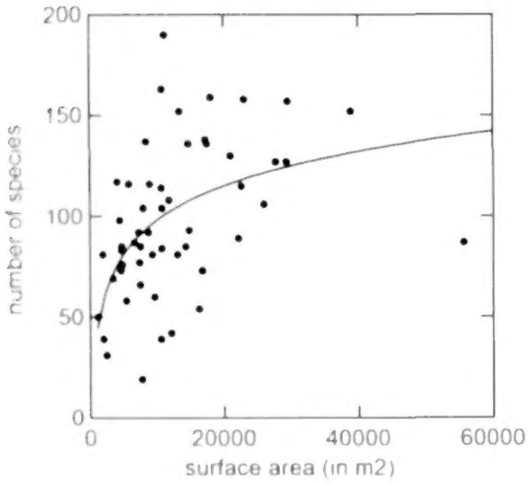

Figure 6. The relation between the number of species and the surface area per sector.

tor 13 around the castle, Wild Meise (43, 44 and 45), the sectors 14, 34 and 36 in the neighbourhood of the castle, the sectors 54 and 59 in the neighbourhood of Machoechel, sectors 10, 11, 18, 67 and 68 that are close to the main entrance and the castle lane, and further the sectors 53 and 61, as well as the herbetum (sector 51). The sectors with an obvious lower than average species richness are partly collections and plant nurseries: the orangery garden (22), the medicinal garden (47), the fruticetum (46), nurseries in sector 39 and 40, and partly other sectors (25, 28, 30, 31, 32, 33, 41) located in the western part of the Domain, and the sectors

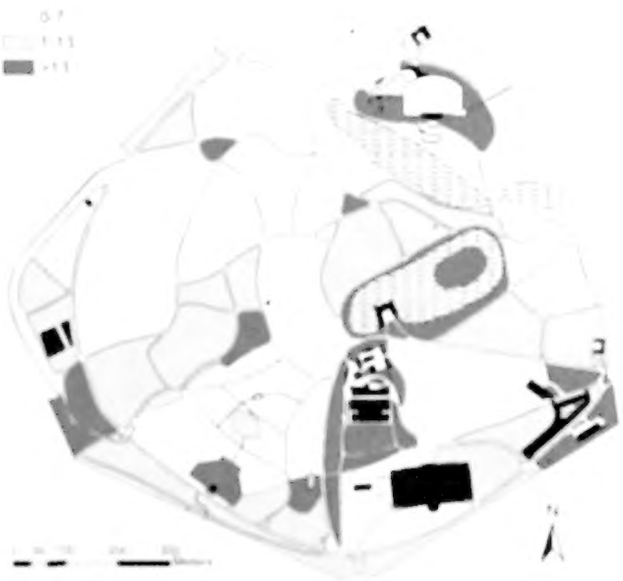

Figure 7. The geographical distribution of the relative species richness per surface area (number per 1000 m²) of the sectors.

55 and 57 close to the Machoechel, as well as sector 12. The geographical distribution of the relative species richness per area of the sectors is shown in figure 7. It shows a rather different image than the map with the numbers of species per sector (figure 5). The only sectors that belong to the highest category in both maps are the sectors 13, 43 and 59, that are very species rich both in absolute numbers and in numbers per area.

The species in appendix 1 are mostly plants that were observed in open air. Beside these species, some other species were found as weeds in containers of orangery plants. Orangery plants are plants that are grown in containers and are placed outside in summertime and are moved to an orangery or greenhouse in the winter. Some non-flowering plants of a large leaved *Oxalis* were present in several containers, as well as indetermined seedlings that look like *Boehmeria*. In the container of a *Phoenix dactylifera* (date palm) *Sibthorpia peregrina* grows and flowers profusely. This is a climbing Scrophulariaceae that originates from Macaronesia and that is grown in greenhouse H of the Plant Palace. This species is listed as naturalized on the list of invasive exotic species in Portugal (see www.hear.org). Apparently it can not survive in our climate, since the species has not been observed outside the containers.

Beside the orangery containers, some undetermined species have been found in an unheated glasshouse in sector 23, where the same species also occur as weeds outside. For example an undetermined *Viola* with silvery patterned leaves seeds freely in the collections there.

The observations made between 2002 and 2010 can be complemented with data of earlier finds in the Domain. In the herbarium at Meise (BR) specimens of seven additional species were found. The oldest one concerns an anonymous herbarium specimen from 1939 mentioning 'down the castle lane (beneden Eeredreef), Meise' of *Succisa pratensis*, an indigenous species that has strongly decreased in frequency in Flanders. The other six specimens concern adventive species (mostly escaped from the collections), that have been collected between 1981 and 1996 by different collectors:

Chenopodium ambrosioides (E. Robbrecht 3157), *Chenopodium capitatum* (J. Loots 581), *Gnaphalium luteoalbum* (D. Geerinck s.n.), *Polypogon monspeliensis* (L. Vanhecke 6399), *Phalaris canariensis* (E. Robbrecht 2911), *Setaria italica* (E. Robbrecht 2995). Other additional data on the Domain are present in Florabank. The most interesting observations are those recorded from 1978 to 1980 by G. Bruynseels: *Elymus repens*, *Geranium columbinum*, *Juncus acutiflorus*, *Nuphar lutea*, *Rumex ×pratensis*, *Sedum telephium*, *Veronica montana*, *Vinca major*, and *Linaria vulgaris*. However, for *Vinca major* it is suspected that it might be an erroneous record of what was in reality *Vinca minor*, a species that is present in the Domain and that was not recorded by him. In 1980 M. Leten found *Campanula rapunculoides* in the Domain. All these species are indigenous species, except *Vinca major*.

Moreover, Florabank contains records made within the IFBL-kilometre squares where the Domain is located. These kilometre squares are areas of 1 × 1 km that are used for the mapping of the flora in Belgium. Since parts of the squares lie outside of the Domain, these records can not be located with certainty within the Domain. The following species have been reported from those 2 squares (observations made by J. De Langhe in 1984 and 1985): *Barbarea vulgaris*, *Atriplex patula*, *Alopecurus myosuroides*, *Erysimum cheiranthoides*, *Campanula rotundifolia*, *Malva neglecta*, *Melilotus albus*, *Lonicera periclymenum*, *Silene latifolia* ssp. *alba*, *Reseda lutea*, *Setaria viridis*, *Stachys palustris*, *Echium vulgare*. Most of these species are ruderal species.

Indigenous character of the vegetation

Not only are the total numbers of species important to evaluate the conservation value of the sectors, but also the identity of the species, especially whether they are indigenous, as discussed in the introduction. That's why the proportion of the 'truly indigenous species' (category 1) within each sector is calculated. Within the Domain the average proportion of category 1 species amounts to 83%. As indicated above, only 60% of the species that occur in the Domain belong to this category, which means that indigenous species occur more frequently (in more sectors) than other categories. A maximum of 93% indigenous species has been found in sectors 33 and 56, while the lowest percentage amounts to only 47% and is found in sector 24. A map with the distribution of the percentage of indigenous species per sector (figure 8) shows that the most indigenous vegetation occurs in the northern part of the Domain, and the lowest percentage occurs in and around the main collections and nurseries, including sector 59.

Rare species

Another factor influencing the value of the vegetation is the occurrence of rare species. In the Flemish plant atlas (Van Landuyt *et al.* 2006) the rarity of species has been computed by means of kilometre square frequency classes (in short KFK). For the present analysis I have retained all the species with a KFK between 1 (= extremely rare) and 4 (= rare). One species with a KFK of 0 has also been observed, these are plants that are regionally extinct in Flanders. Several species that were found in this study are not mentioned in the atlas, so their KFK-value is not known; these are mainly exotic species.

Table 2 gives a list of the extremely rare to rare plant species of the Domain, with their KFK-value and category, as defined above. In

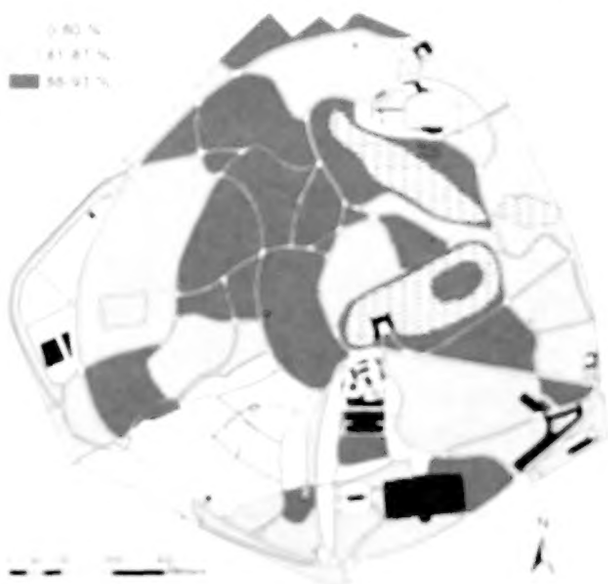

Figure 8. A map with the distribution of the percentage of indigenous species per sector.

Table 2. List of the extremely rare to rare plant species of the Domain, with indication of their KFK-value and of their plant category, as defined in the text; see above for definitions of the categories.

Name	KFK	Cat.
Ailanthus altissima	4	3
Alchemilla mollis	2	2
Amaranthus albus	3	3
Amaranthus blitum	4	1
Anthemis arvensis	4	3
Arum italicum	3	4
Asplenium adiantum-nigrum	2	1
Asplenium scolopendrium	4	1, 4,6
Asplenium trichomanes	4	1
Barbarea verna	2	2
Bromus inermis	2	1
Campanula trachelium	4	1
Cardaminopsis arenosa	3	3
Carex divulsa ssp divulsa	2	5
Carex flacca	4	1
Carex muricata ssp lamprocarpa	1	5
Carex pendula	3	1
Carex spicata	4	1
Carex vulpina	2	3
Catapodium rigidum	1	3
Centaurium pulchellum	4	1
Chamaesyce humifusa	1	2
Chenopodium glaucum	4	3
Chrysosplenium oppositifolium	4	1
Conium maculatum	4	3
Conyza sumatrensis	4	2
Cornus sericea	2	3
Cotoneaster cf dielsianus	1	3
Cotoneaster horizontalis	4	2
Cotoneaster salicifolius	1	2
Crassula helmsii	2	3
Crepis paludosa	4	1
Dactylis polygama	1	5
Dactylorhiza fuchsii	3	6
Dactylorhiza maculata	4	6
Dactylorhiza praetermissa	2	6
Dipsacus pilosus	3	3
Doronicum pardalianches	1	3
Duchesnea indica	4	2
Elymus caninus	3	3
Epilobium obscurum	4	1
Erigeron karvinskyanus	2	2
Festuca brevipila	2	1
Fumaria capreolata	2	1,3
Fumaria parviflora	0	3
Hieracium aurantiacum	3	2
Hieracium lachenalii	4	1
Hypericum hirsutum	2	1
Impatiens noli-tangere	3	1
Inula helenium	1	3
Lamium maculatum variegatum	3	3
Lathraea clandestina	4	6
Lemna minuta	3	2
Ligustrum ovalifolium	4	3
Lonicera nitida	1	3
Lunaria annua	4	2
Luzula forsteri	1	5
Luzula sylvatica	4	5
Mentha pulegium	1	3
Mespilus germanica	4	1
Misopates orontium	4	3
Narcissus pseudonarcissus	4	6
Oenanthe pimpinelloides	1	3
Panicum capillare	3	3
Parietaria judaica	3	3
Parietaria officinalis	2	1
Pentaglottis sempervirens	2	2
Phytolacca esculenta	1	2
Plantago media	4	3
Poa chaixii	1	5
Polystichum aculeatum	2	1
Polystichum setiferum	1	1
Portulaca oleracea	3	2
Potentilla norvegica	3	2
Ranunculus lingua	2	3
Rhinanthus minor	4	6
Ribes alpinum	2	4
Rosa multiflora	1	2
Rubus laciniatus	2	3
Sambucus ebulus	3	3
Sanicula europaea	4	1
Sedum album	3	3
Sedum rupestre	3	2
Selinum carvifolia	3	1
Setaria pumila	4	3
Sherardia arvensis	4	1
Stellaria pallida	3	1
Syringa vulgaris	3	4
Trifolium micranthum	3	1
Ulex europaeus	4	3
Verbascum densiflorum	3	1
Veronica polita	3	1

the Domain 92 species with a KFK between 0 and 4 have been encountered, this is 16 % of the total number of species. One regionally extinct species was found, namely *Fumaria parviflora*, which grows as weed in the herbetum (Ronse & Groom 2011). Five of the rare species have only been recorded from the inner court of the main building, according to Hoste & Geerinck (2011). Sixteen species are extremely rare (KFK 1), 19 are rare (KFK 2) and 57 scarce (KFK 3 of 4). Of all these species only 29 % can be viewed as truly indigenous. This is less than half of the overall proportion of the truly indigenous species in the Domain (60 %), which means that among the rare spe-

cies relatively few truly indigenous plants are present.

This also becomes obvious from figure 9 that shows the proportion of classes KFK1 to KFK4 within each category. The proportion of all rare categories together (KFK 1-4) varies exceedingly within each category: within the truly indigenous species the proportion of rare species only reaches 8 %, within the collection escapes and the stinsen plants this increases to 25%, within the external neophytes it is 30%, while 75% of the wood lawn neophytes and 100% of category 6 is rare! This means that the deliberately introduced indigenous species that have been introduced since the Domain became a botanic garden, all are rare species. The extremely rare species (KFK1) are mainly collection escapes, external neophytes and wood lawn neophytes; only one species (*Polystichum setiferum*) is a truly indigenous species. Within the very rare species (KFK2) nearly one third is truly indigenous, and within the group of the rare or rather rare species somewhat more than one third are indigenous.

Per sector the number of rare species varies between 0 and 14. The geographic distribution of the rare species is shown in figure 10; this shows all sectors with more than five rare species, and shows whether or not more than 20% of the rare species are truly indigenous. This distribution shows some resemblance to the

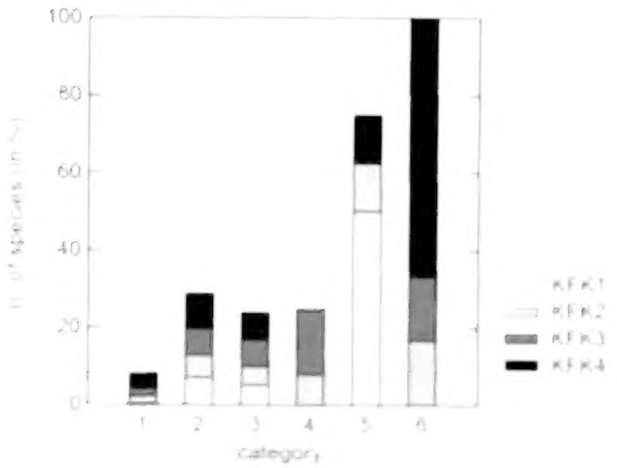

Figure 9. Percentage of rare species (KFK-class 1 to 4) within each plant category (see the text and table 1 for definitions of the categories). KFK1 extremely rare, KFK2 very rare, KFK3 rare, KFK4 rather rare.

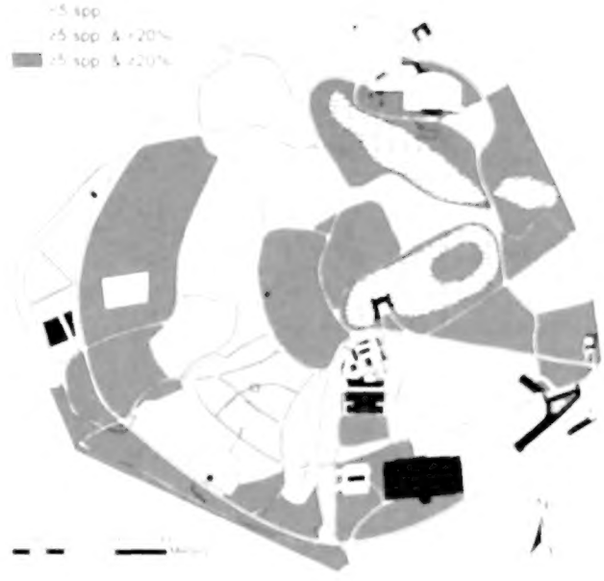

Figure 10. The geographic distribution of the rare species.

map of the species richness per sector of the 18 sectors with many rare species from which more than 20% are indigenous, 11 contain more than 120 species. I found a high correlation (0.67) between the number of rare species and the number of all other species per sector.

Several plants found in the Domain are listed on the Red List of the vascular plants of Flanders (Van Landuyt *et al.* 2006), such as *Fumaria parviflora*, listed as 'regionally extinct', here a collection escape. Two species from the category 'critically endangered' grow in the Domain: *Mentha pulegium* and *Oenanthe pimpinelloides*. Both species are collection escapes as well (on *O. pimpinelloides*, see Ronse 2005). In the category 'endangered' *Catapodium rigidum* occurs, also a collection escape in Meise, and in the category 'vulnerable' we find *Anthemis arvensis*, *Dactylorhiza maculata*, *Hieracium lachenalii* and *Rhinanthus angustifolius*. All of these species have been planted in the Domain or have escaped from the collections, except probably *H. lachenalii*.

Ancient forest plants

In the Domain a lot of trees grow. About one tenth of all species in appendix 1 are woody, and in the Domain 43 sectors are completely or partly wooded. Nearly all mapped sectors contain wooded areas, except the nurseries and one sector that exclusively consists of grass-

land. The total proportion of woodland lies below 50%, because many sectors are only partly covered with trees. Only 15 sectors are totally covered with trees. The total wooded area of the Domain has been found with GIS-analysis to cover 41,7 ha, this is about 45 % of the total surface area of the Domain. The grasslands and lawns cover 36,5 ha, this is 40% of the total area, while the remaining 5% are covered by collections, plant nurseries and buildings.

The occurrence of ancient forest plants in the Domain has been investigated. These are species that mostly grow in 'ancient' forests. They have been found to show an ecology that is different from species that also can colonize more recent forests. In Belgium 'ancient forests' are defined as areas that have remained wooded since at least 1775, the year when the historical so-called Ferraris map was drawn. The duration of the wooded period can differ between countries according to the date of the available historical maps of land use (Honnay *et al.* 1998). I have followed the list of Hermy *et al.* (1999), in order to decide whether a species is an ancient forest plant or not. This list is based on data from 22 studies made in different European countries. I have chosen species that have been mentioned as ancient forest plant by at least two studies.

In total, 38 ancient forest plant species have been found. The location of the sectors with a high proportion and/or number of ancient forest plants is represented in figure 11. In twenty sectors more than 15 % of the species or more than 20 species are ancient forest species. These sectors lie close to the main entrance, or lie in a zone in the northern part of the Domain, or lie in the valley fen wood in sector 43. Ten sectors possess more than 20% or more than 20 species of ancient forest plants, and these form a continuous area. They are the sectors 11, 12, 18 and 67, the sectors 30, 31 and 32, sector 26, and the valley fen wood of sector 43 plus sector 44. The ancient character of most of these sectors agrees more or less with what is known of the historic management of these areas: the sectors 30, 31 and 32 form the old forest of the former castle of Meise, the valley fen wood of sector 43 has remained nearly undisturbed

Figure 11. The geographic distribution of the sectors with a high proportion of ancient forest plants.

except for coppicing, and the forests near the castle lane of Bouchout and to the east of the castle also have been there for a long time. The former forests of the castle of Bouchout (sectors 59 and neighbourhood) don't possess many ancient forest plants. This can readily be explained by the fact that they have been cut down at the beginning of the nineteenth century, that some excavations have been executed, and that they have only been reforested in the second half of the twentieth century.

Some sectors with many ancient forest plants also possess a high total number of species: this is the case for the sectors 43, 44 and 26, and also for the sectors 11, 67 and 18. A rather high correlation (0.51) was found between the total number of species and the number of ancient forest species.

Acidophilic species

Most plants in the Domain of the National Botanic Garden are species that favour neutral or basic soils that prevail in the 'Leemstreek', the area with mostly loamy soils. However, locally some species can occur that are known as acidophiles, for example in (ancient) forests of tree species that form acidic litter, such as beech. The selection of (slightly) acidophilic species was made by use of the tables of Ellenberg (Ellenberg *et al.* 1992), taking species with a R value of 2 to 5. In the Domain these

are *Carex divulsa*, *Deschampsia flexuosa*, *Hieracium lachenalii*, *Luzula campestris*, *L. forsteri*, *L. pilosa*, *L. sylvatica*, *Milium effusum*, *Oxalis acetosella*, *Poa chaixii* and *Polystichum setiferum*.

Figure 12 is a map showing the distribution of the sectors with more than two of the above listed acidophilic species. This is the case for the sectors 10, 11 and 12 that lie in the neighbourhood of the castle lane, and the sectors 26, 29, 15, 32, 34 and 38 thay lie in the northern half of the Domain; the sectors 44 en 67 each have two such species. No correlation was found between the occurrence of acidophilic species and of rare species, a correlation of 0.27 was found with the total number of species and a correlation of 0.39 with the occurrence of ancient forest plants. This latter correlation can probably be explained by the acidifying effect of the litter that occurs under some trees after a longer period of time.

Figure 12. The geographic distribution of acidophilic species.

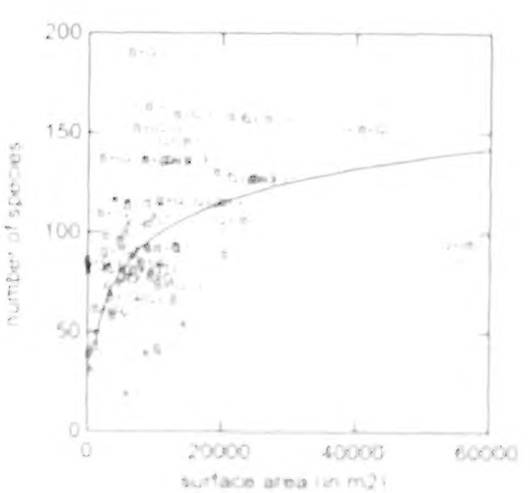

Figure 13. Relative species richness and land use type per sector. B: woodland. B+(G): forest with small parts of grassland. B+G: approximately equal parts of woodland and grassland. G+(B): grassland with small parts of woodland. G: grassland. K: collections and plant nurseries.

Biodiversity, land use and land management

The relation between the species richness per sector and the actual land use is shown in figure 13; this figure is the same as figure 6 but with additional indication of the land use per sector. The types of land use that have been distinguished here are B: woody sectors, B+(G): sectors with mainly forest and small parts of grassland, B+G: sectors with approximately equal parts of woodland and grassland, G+(B): mainly grassland with small parts of woodland, G: grassland, and K: collections and plant nurseries. Of the 54 mapped sectors 15 consist of only woodland (B), 10 consist of mainly forest with some grassland (B+(G)), 9 have equal parts of woods and grassland (B+G), 9 mainly grassland with some woody parts (G+(B)), only 1 sector consists exclusively of grassland, and 10 sectors contain collections or nurseries. The figure shows that most land use types are equally distributed above and under the curve. The collections and nurseries tend to have a lower than average species richness per surface area, while sectors with mixed land use types (B+G) often score higher than average.

Figure 14 shows the average proportion of rare species per sector for the different types of land use. It appears that the proportion of rare species is the smallest in forests and in sectors with mixed land use, the larger the proportion of woodland per sector, the smaller the proportion of rare species. The largest proportion of rare species occurs in collections and nurseries and in sectors with (predominantly) grassland.

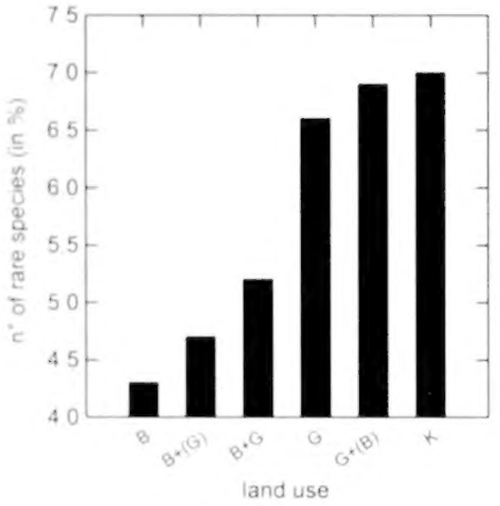

Figure 14. Percentage of rare species (total of KFK1-4) and land use type per sector.

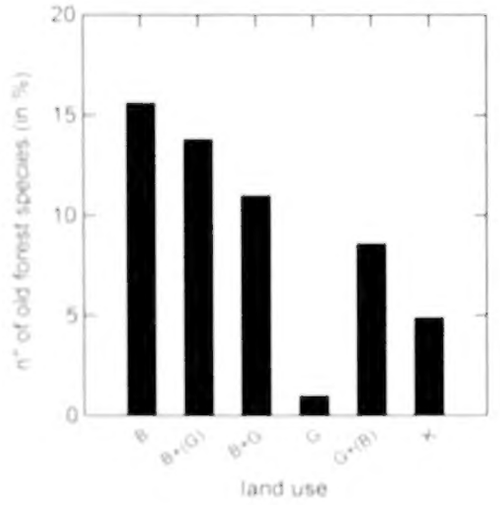

Figure 15. Percentage of ancient forest plants and land use type per sector.

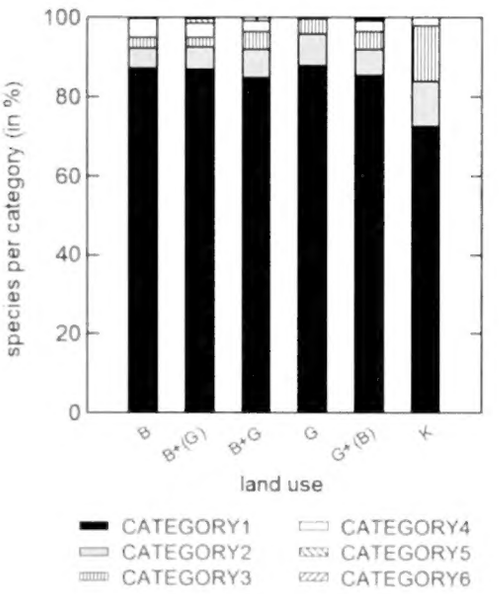

Figure 16. Percentage of plant categories per land use type.

Not surprisingly, we find the opposite trend for the proportion of ancient forest plants, that are mainly present in more woody sectors, and that are under-represented in collections and nurseries, but also in grasslands (figure 15).

Finally an analysis was made of the proportion of the plant categories within each type of land use (figure 16). It shows that the collections and nurseries possess relatively few truly indigenous species, but many external neophytes (category 2) and collection escapes (category 3), in comparison with other types of land use. Wood lawn neophytes (category 5) are almost restricted to sectors with both woodland and grassland, while the plants of category 6 are hardly present in any land use type.

Now let us investigate the influence of the management of grasslands on the compositon of the vegetation. For the grasslands, a differential mowing management was introduced in 2006, with different treatments of mowing frequency

Table 3. The grassland management types at the National Botanic Garden.

Management type	Abbreviation	Mowing height	Mowing frequency
Utility lawn	G*	3-4 cm	Weekly
Scenic lawn	L	8-10 cm	Every two weeks
Wood lawn	B	3-4 cm	Weekly or every two weeks, end of June till September
Natural grassland	N	3-4 cm	1x after 15 July (or a 2nd time at the end of September)

* sectors with mainly utility lawn and parts of other mowing regimes are represented by G+.

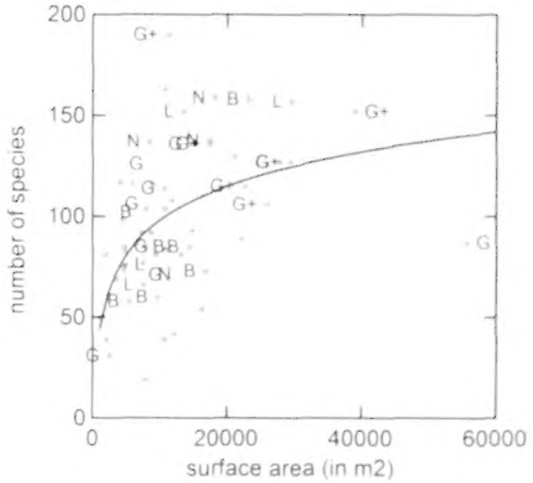

Figure 17. Relative species richness and grassland mowing management per sector. G: utility lawn, G+: utility lawn mixed with other types, B: wood lawn, L: scenic lawn, N: natural lawn.

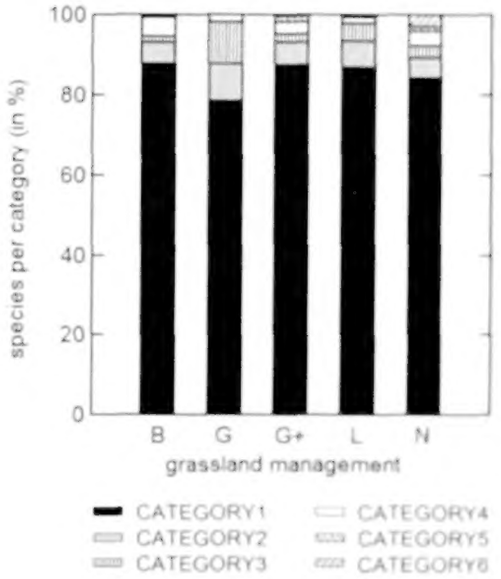

Figure 20. Percentage of plant categories per grassland management type.

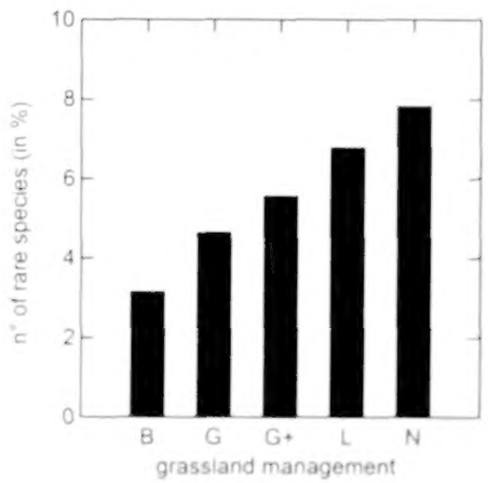

Figure 18. Percentage of rare species (total of KFK1-4) and grassland mowing management per sector.

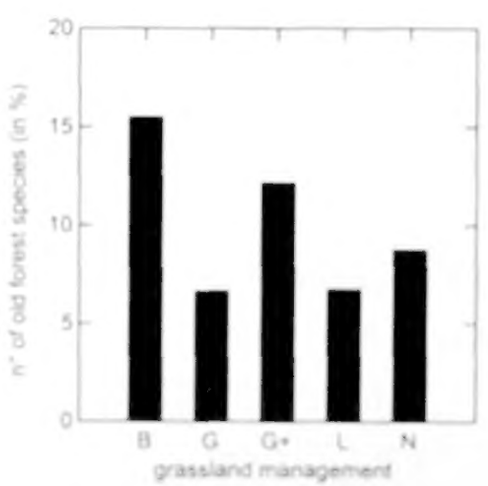

Figure 19. Percentage of ancient forest plants and grassland mowing management per sector.

and cut height (Ausloos 2006). The grassland management types are defined in table 3.

The species richness by sector as well as the management type for grassland sectors is shown in figure 17. It tells us that the sectors that are mown as woodland lawn possess a lower than average number of species, while this tends to be the reverse for scenic lawns. The number of rare species under different types of grassland management is represented in figure 18. Woodland lawns possess less rare species than other types of grasslands, while natural grasslands possess the highest number of rare species. On the contrary, more ancient forest plants are present in woodland lawns (figure 19), while they make up a smaller proportion of the species present in utility lawns and in scenic lawns. The percentage proportion of the different plant categories differs somewhat according to figure 20: the proportion of indigenous species (category 1) is lower in utility lawns, but external neophytes and collection escapes are well represented there. Stinsen plants (category 4) occur mainly in wood lawns and in natural grasslands. Woodland lawn neophytes occur in most grassland types except in utility lawns, and the species from category 6 (deliberately introduced indigenous plants), mainly orchid species, are remarkably often present in natural grasslands.

On the whole, the results shown by figure 17 to 20 indicate that there is a difference in number of species and in the species composition of the grasslands according to their mowing management. However, it it not clear whether these differences are a result of the different mowing management since 2006. Indeed, it is also possible that the selection of the mowing type per sector was influenced by their initial composition and species richness in 2006. It is probable that the sectors that have been selected for more natural types of grassland, were mainly those sectors that already had a rather high initial natural value. Moreover, with this dataset no distinction could be made between the period before and after 2006. On the other hand, the observations in the field make it obvious that much more flowering takes place in the less frequently and less shortly mown parts of the lawns than in the other parts. For example, a massive flowering of *Leucanthemum vulgare* took place in 2009 by the Amelvonnebeek close to the castle. Another example is the expansive or even explosive growth of some indigenous orchid species (*Dactylorhiza* spp.) in the lawns that have been mown as natural grasslands.

Conclusion

In the Domain of the National Botanic Garden of Belgium from 2002 to 2010 in total 586 species of 'truly wild' and naturalized vascular plants have been found. Moreover, 17 other species from earlier sources can be added to this list. Sixty percent of all species are truly indigenous species; the other species can be classified as collection escapes, external neophytes, stinsen plants, wood lawn neophytes and deliberate introductions of indigenous species in (semi-) natural conditions. The truly indigenous species occur more frequently than other categories in the Domain, as they make up 83% of the species found per sector on average.

In this study up to 190 species per sector were counted. The most species rich sectors for vascular plants are situated along the castle of Bouchout and the castle lane, and secondly in and by the valley fen wood along the Amelvonnebeek in the western part of the Domain; the herbetum and the neighbouring sector 53 are very species rich as well.

The number of (somewhat to extremely) rare species amounts to 92, or 16% of all species that have been observed in the Domain. Only few of them are truly wild indigenous species, but most of them belong to the collection escapes, neophytes and deliberate introductions. The same holds for the Red List species that have been found. There is even a species that is extinct in Flanders, present as a collection escape.

The presence of ancient forest plants in the Domain has also been investigated, and 38 of such species were found. Their local distribution concords with what is known of the historical management and land use of the Domain, and it is also highly correlated with the total species richness of the sectors. As another component of biodiversity, the occurrence and distribution of acidophilic species in the Domain was also examined; it showed some correlation with the ancient forest species.

The actual land use affects the biodiversity. In the Domain the highest number of species per area was found in sectors with both grassland and woodland. A higher number of species in areas with high habitat diversity has also been reported on a regional scale for Flanders by Honnay et al. (2003). Collections and nurseries contain a low number of species on the whole. However, they often contain many rare species, mostly collection escapes. The number or rare species is lower in woodland than in grassland; on the other hand woodland obviously possesses the highest number of ancient forest plants.

A relationship was found between the number of species and the species composition in grasslands on one hand, and the mowing regime on the other hand. Natural grasslands, that are mown only once or twice a year, possess the highest number of rare species; in this type the most orchids and other species of category 6 (deliberate indigenous introductions) are present. Wood lawns possess markedly lower total numbers of species and numbers of rare species, but they contain more ancient for-

est plants and stinsen plants. Utility lawns, i.e. lawns that frequently are cut very short, consist of relatively few truly indigenous plant species, but have many neophytes and collection escapes.

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References

Ausloos G. (2006) – Graslanden in de Plantentuin en hun beheer. *In* Tuiniersursus. Meise, Nationale Plantentuin van België.

Bakker P. & Boeve E. (1985) – Stinzenplanten. Zutphen & 's-Graveland, Terra & Vereniging tot Behoud van Natuurmonumenten in Nederland.

Cope T. (2009) – The Wild Flora of Kew Gardens. A cumulative checklist from 1759. Kew, Kew Publishing.

De Meyere D. (1998) – Ontwikkelingsperspectieven voor de Openluchtverzamelingen van de Nationale Plantentuin van België. Meise, Nationale Plantentuin van België.

De Saeger S., Delafaille S., Heirman J. & Paelinckx D. (2000) – Biologische waarderingskaart, versie 2, kaartbladen 23. Brussel, Instituut voor Natuurbehoud.

Devos A. (1870a) – Les plantes naturalisées ou introduites en Belgique. *Bull. Soc. Roy. Bot. Belg.* **9**: 5-42.

Devos A. (1870b) – Enumération systématique des plantes naturalisées ou introduites en Belgique. *Bull. Soc. Roy. Bot. Belg.* **9**: 43-122.

Ellenberg H., Weber H.E., Düll R., Wirth V., Werner W. & Paulissen D. (1992) – Zeigerwerte von Pflanzen in Mitteleuropa. 3. verbesserte und erweiterte Auflage. Göttingen, Verlag Erich Goltze KG.

Hermy M., Honnay O., Firbank L., Grashof-Bokdam C. & Lawesson J.E. (1999) – An ecological comparison between ancient and other forest plant species of Europe, and the implication for forest conservation. *Biological Conservation* **91**: 9-22.

Honnay O., Degroote B. & Hermy M. (1998) – Ancient-forest plant species in Western Belgium: a species list and possible ecological mechanisms. *Belg. Journ. Bot.* **130 (2)**: 139-154.

Honnay O., Piessens K., Van Landuyt W., Hermy M. & Gulinck H. (2003) – Satellite based land use and landscape complexity indices as predictors for regional plant species diversity. *Landscape and urban planning* **63**: 241-250.

Hoste I. & Geerinck D. (2011) – The vegetation of the enclosed courtyard at the herbarium building. *Scripta Bot. Belg.* **47**: 145-153.

Klijn F. & H.A. the Haes U. (1990) – Hiërarchische ecosysteemclassificatie. Voorstel voor een eenduidig begrippenkader. *Landschap* **7 (4)**: 215-233.

Lambinon J., Delvosalle L. & Duvigneaud J. (2004) – Nouvelle flore de la Belgique, du Grand-Duché de Luxembourg, du Nord de la France et des Régions voisines, 5e édition. Meise, Jardin botanique national de Belgique.

Ronse A. (2005) – Oenanthe pimpinelloides: bedreigde soort of invasieve neofyt? *Dumortiera* **84**: 11-14.

Ronse A. (2011a) – The 'truly' indigenous flora. *Scripta Bot. Belg.* **47**: 59-66.

Ronse A. (2011b) – External neophytes. *Scripta Bot. Belg.* **47**: 77-88.

Ronse A. (2011c) – 'Botanic garden escapes' from the living collections at the Botanic Garden. *Scripta Bot. Belg.* **47**: 89-111.

Ronse A. (2011d) – Stinsen plants and other deliberate introductions in the (semi-) natural zones of the Botanic Garden. *Scripta Bot. Belg.* **47**: 67-75.

Ronse A. & Groom Q. (2011) – Fumaria parviflora in Belgium, extinct or not? *Scripta Bot. Belg.* **47**: 125-126.

Ronse A. & Leten M. (2011) – Wood lawn neophytes, historical park relicts. *Scripta Bot. Belg.* **47**: 113-121.

Ronse A. & Vidts S. (2011) – A short history of the land use and vegetation of the Botanic Garden. *Scripta Bot. Belg.* **47**: 19-26.

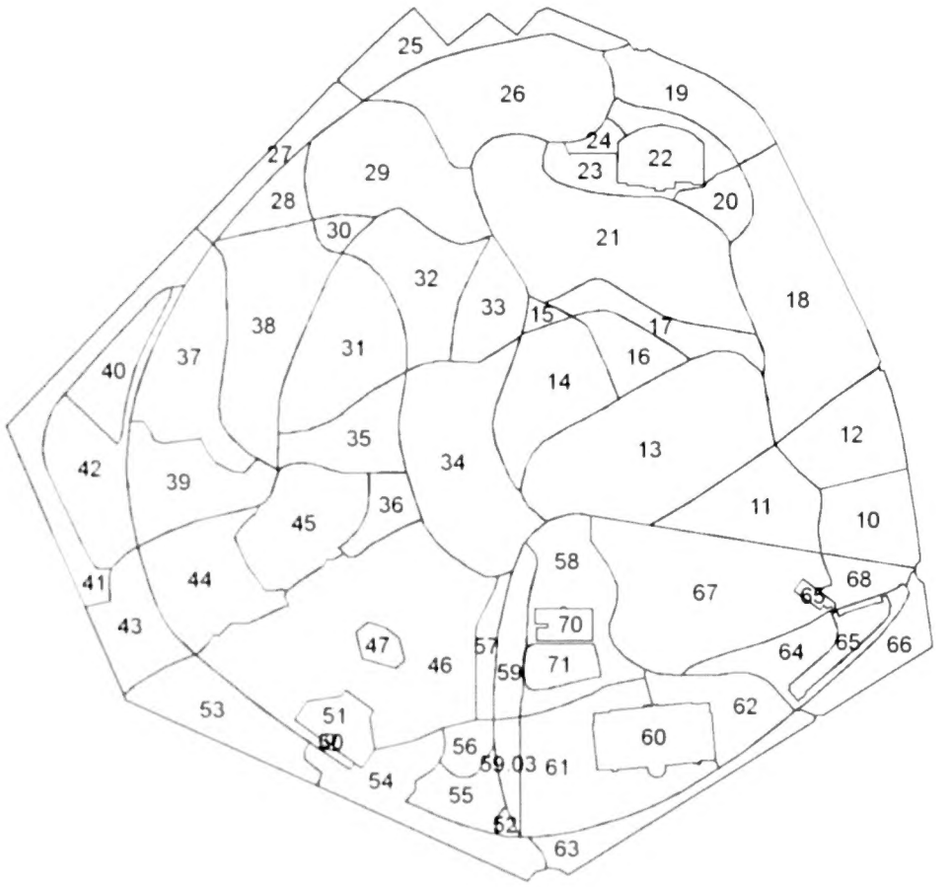
Vanhecke L. (2008) – Naar een Ruimtelijk Masterplan voor de Nationale Plantentuin van België. Elementen en signaalkaarten voor een ecologische invalshoek. Meise, Nationale Plantentuin van België.

Van Landuyt W., Hoste I., Vanhecke L., Van den Bremt P., Vercruysse W. & De Beer D. (2006) – Atlas van de flora van Vlaanderen en het Brussels Gewest. Brussel & Meise, INBO, Nationale Plantentuin van België & Flo.Wer.

Van Mello W. (2001) – Inventarisatie van enkele kenmerkende soorten van de voorjaarsvegetatie in het Domein van Bouchout. Meise, Nationale Plantentuin van België.

Verloove F. (2006) – Catalogue of neophytes in Belgium (1800-2005). *Scripta Botanica Belgica* **39**. Meise, National Botanic Garden of Belgium.

Appendix 1. List of vascular plant species recorded from the Domain of the National Botanic Garden between 2002 and 2010. **Cat.**: Category; **N**: number of sectors. For the location of the sectors, see the map below.



Name	Cat.	N	List of sectors
Acer campestre	1	7	16, 18, 26, 35, 36, 38, 71
Acer platanoides	4	31	10, 11, 12, 13, 14, 17, 18, 19, 21, 24, 26, 27, 30, 31, 32, 34, 35, 36, 38, 41, 42, 43, 44, 45, 56, 58, 59, 64, 65, 66, 67
Acer pseudoplatanus	1	49	10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 38, 39, 40, 41, 42, 43, 44, 45, 51, 53, 54, 55, 56, 57, 58, 59, 61, 62, 64, 65, 66, 67, 68
Acer saccharinum	3	1	53
Achillea millefolium	1	7	13, 14, 21, 34, 41, 51, 54
Achillea ptarmica	1	1	67
Adlumia fungosa	3	1	23
Adoxa moschatellina	1	11	13, 14, 18, 19, 27, 36, 41, 43, 44, 45, 54
Aegopodium podagraria	1	30	12, 13, 14, 16, 17, 18, 19, 20, 21, 24, 25, 26, 27, 31, 34, 35, 36, 38, 41, 43, 44, 45, 54, 56, 59, 61, 63, 64, 66, 71
Aesculus hippocastanum	4	32	11, 12, 13, 14, 16, 18, 19, 21, 23, 24, 25, 26, 27, 29, 31, 32, 34, 35, 36, 38, 41, 42, 43, 44, 57, 58, 59, 61, 64, 66, 67, 68
Aesculus parviflora	3	1	18
Aethusa cynapium	3	2	41, 46
Agrimonia eupatoria	1	4	11, 51, 55, 68
Agrimonia repens	3	1	51
Agrostis canina	1	3	33, 34, 45

Agrostis capillaris	1	16	13, 16, 18, 20, 21, 26, 27, 29, 34, 43, 45, 54, 55, 58, 62, 64
Agrostis gigantea	1	1	38, 65
Agrostis stolonifera	1	36	10, 12, 13, 15, 17, 18, 19, 25, 26, 27, 29, 31, 33, 34, 35, 38, 39, 41, 42, 43, 44, 45, 46, 47, 51, 53, 54, 55, 58, 59, 61, 62, 63, 67, 68, 71
Ailanthus altissima	3	1	63
Ajuga reptans	1	28	10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 24, 26, 27, 28, 29, 32, 34, 38, 43, 44, 45, 53, 56, 57, 64, 67, 68
Alchemilla mollis	3	1	51
Alisma plantago-aquatica	1	2	13, 16
Alliaria petiolata	1	30	10, 13, 14, 15, 16, 17, 18, 19, 21, 24, 26, 27, 28, 31, 32, 33, 34, 35, 36, 38, 41, 42, 43, 44, 45, 54, 56, 59, 61, 66
Allium schoenoprasum	3	6	11, 27, 29, 67, 68, 71
Allium sphaerocephalon	3	1	51
Allium ursinum	1	45	10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 38, 41, 42, 43, 44, 45, 46, 53, 54, 56, 57, 58, 59, 61, 63, 64, 66, 67, 68
Allium vineale	1	6	29, 38, 41, 64, 66, 71
Alnus glutinosa	1	10	13, 14, 18, 31, 34, 38, 41, 43, 44, 45
Alnus incana	4	3	18, 43, 44
Alopecurus geniculatus	1	10	13, 29, 34, 36, 42, 45, 46, 59, 61, 67
Alopecurus pratensis	1	8	33, 38, 43, 44, 45, 54, 59, 71
Amaranthus albus	3	1	46
Amaranthus blitum	2	7	20, 42, 46, 51, 61, 62, 63
Amaranthus retroflexus	2	1	21
Ambrosia artemisiifolia	3	2	14, 34
Ammi visnaga	3	1	47
Amorpha californica	3	2	34, 46
Anagallis arvensis	1	16	13, 18, 20, 21, 23, 45, 46, 51, 53, 54, 61, 62, 63, 66, 67, 71
Anemone nemorosa	1	41	10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 38, 41, 43, 44, 45, 46, 54, 56, 58, 59, 61, 63, 64, 66, 67, 68
Angelica sylvestris	1	13	13, 16, 19, 33, 34, 35, 36, 43, 44, 45, 56, 57, 59
Anthemis arvensis	3	5	46, 54, 55, 61, 67
Anthoxanthum odoratum	1	10	13, 21, 34, 38, 44, 45, 51, 57, 59, 62
Anthriscus sylvestris	1	31	10, 12, 13, 14, 15, 16, 18, 19, 20, 21, 24, 26, 27, 28, 29, 34, 35, 36, 38, 42, 43, 45, 54, 55, 56, 57, 58, 59, 64, 66, 67
Apera spica-venti	3	1	34
Apium nodiflorum	1	5	13, 34, 43, 44, 57
Aquilegia vulgaris	3	3	47, 51, 53
Arabidopsis thaliana	1	12	23, 38, 40, 46, 47, 51, 53, 54, 59, 61, 63, 71
Arctium minus	1	8	10, 31, 38, 44, 45, 53, 54, 66
Arenaria serpyllifolia	1	3	23, 38, 53
Arrhenatherum elatius	1	15	13, 14, 17, 26, 27, 32, 33, 34, 36, 43, 44, 45, 59, 62, 66
Artemisia vulgaris	1	4	13, 14, 34, 51
Arum italicum	4	12	18, 19, 25, 27, 29, 34, 36, 38, 46, 57, 58, 61
Arum maculatum	1	45	10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 38, 41, 42, 43, 44, 45, 46, 53, 54, 55, 56, 58, 59, 61, 63, 64, 66, 67, 71
Asarina procumbens	3	2	51, 58
Asplenium adiantum-nigrum	1	1	65
Asplenium ruta-muraria	1	2	22, 58

Asplenium scolopendrium	1, 4, 6	4	18, 43, 61, 65
Asplenium trichomanes	1	1	65
Athyrium filix-femina	1	26	10, 11, 12, 16, 18, 19, 26, 29, 30, 31, 32, 33, 34, 35, 36, 38, 39, 41, 42, 43, 44, 45, 54, 66, 67, 68
Atriplex prostrata	1	3	62, 63, 71
Aucuba japonica	3	3	10, 24, 63
Barbarea verna	3	1	10
Bellis perennis	1	45	10, 11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 23, 24, 25, 26, 27, 28, 29, 31, 33, 34, 38, 39, 40, 42, 43, 44, 45, 46, 47, 51, 53, 54, 55, 57, 58, 59, 61, 62, 63, 64, 66, 67, 68, 71
Berula erecta	1	1	43
Betula jacquemontii	3	1	65
Betula pendula	1	9	11, 21, 22, 26, 38, 45, 62, 65, 68
Betula pubescens	1	2	63, 65
Betula raddeana	3	1	42
Betula x aurata	1	1	65
Bidens tripartita	1	1	13
Borago officinalis	3	1	10
Brachypodium sylvaticum	1	37	10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 24, 25, 26, 27, 29, 31, 33, 34, 35, 36, 38, 39, 41, 42, 43, 44, 45, 54, 56, 58, 59, 64, 65, 66, 67, 68
Brassica juncea	3	1	43
Brassica rapa	2	3	13, 20, 43
Bromus hordeaceus	1	3	38, 43, 61
Bromus inermis	2	1	38
Bromus sterilis	1	1	67
Buddleja davidii	2	8	18, 19, 24, 36, 47, 61, 62, 65
Bunias orientalis	3	1	51
Calamagrostis epigejos	1	2	33, 65
Caltha palustris	1	3	21, 43, 57
Calystegia sepium	1	14	13, 18, 21, 23, 36, 40, 41, 43, 44, 46, 47, 54, 66, 67
Campanula trachelium	1	1	43
Capsella bursa-pastoris	1	9	20, 23, 46, 47, 51, 59, 61, 63, 71
Caragana arborescens	3	2	46, 63
Cardamine amara	1	1	43
Cardamine flexuosa	1	35	10, 11, 13, 15, 16, 17, 18, 19, 20, 23, 24, 25, 26, 27, 28, 29, 32, 36, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 54, 61, 63, 65, 66, 68, 71
Cardamine hirsuta	1	14	11, 23, 41, 45, 46, 51, 54, 57, 61, 63, 65, 66, 68, 71
Cardamine pratensis	1	35	10, 11, 12, 14, 15, 16, 17, 18, 19, 20, 21, 24, 26, 27, 28, 29, 34, 38, 39, 42, 44, 45, 46, 51, 54, 55, 56, 57, 58, 59, 62, 64, 67, 68, 71
Cardaminopsis arenosa	3	1	61
Carduus crispus	1	1	34
Carex acuta	1	4	13, 34, 54, 57
Carex acutiformis	1	4	21, 34, 44, 57
Carex disticha	1	2	13, 38
Carex divulsa	5	5	11, 26, 38, 44, 67
Carex flacca	1	1	44
Carex hirta	1	15	12, 13, 16, 18, 21, 43, 44, 46, 53, 55, 56, 57, 59, 62, 63
Carex muricata ssp. lamprocarpa	5	2	14, 67
Carex pendula	1	6	11, 18, 19, 38, 53, 65
Carex pseudocyperus	1	1	19
Carex remota	1	25	11, 12, 13, 14, 15, 16, 17, 18, 19, 26, 29, 30, 31, 32, 33, 35, 36, 38, 43, 44, 45, 53, 54, 56, 67
Carex riparia	1	2	13, 57
Carex spicata	1	2	21, 29

Carex sylvatica	1	33	10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 24, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 38, 41, 43, 44, 45, 54, 58, 59, 64, 67, 68
Carex vulpina	3	1	23
Carpinus betulus	1	44	10, 11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 38, 39, 41, 42, 43, 44, 45, 46, 51, 54, 55, 56, 58, 59, 65, 66, 67, 68, 71
Castanea sativa	1	30	11, 12, 13, 18, 19, 21, 24, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 38, 39, 41, 42, 43, 44, 54, 63, 64, 66, 67, 68
Catalpa x erubescens	3	1	58
Catapodium rigidum	3	1	23
Centaurea jacea	1	3	20, 59, 62
Centaurium erythraea	1	2	13, 64
Centaurium pulchellum	1	1	14
Cerastium fontanum	1	41	10, 11, 13, 14, 16, 17, 18, 19, 20, 21, 24, 25, 26, 27, 28, 29, 31, 32, 38, 39, 40, 42, 43, 44, 45, 46, 51, 53, 54, 55, 57, 58, 59, 61, 62, 64, 65, 66, 67, 68, 71
Cerastium glomeratum	1	43	10, 11, 12, 14, 15, 18, 19, 21, 23, 24, 25, 26, 27, 28, 29, 31, 32, 34, 36, 38, 40, 42, 43, 44, 45, 46, 47, 51, 53, 54, 55, 56, 57, 58, 59, 61, 62, 63, 64, 66, 67, 68, 71
Cercidiphyllum japonicum	3	3	27, 58, 63
Chaenorrhinum minus	3	4	23, 51, 61, 62
Chaerophyllum temulum	1	3	13, 34, 66
Chamaesyce humifusa	2	3	23, 46, 51
Chelidonium majus	1, 3	4	32, 38, 43, 51
Chenopodium album	1	9	10, 13, 20, 26, 34, 51, 54, 61, 71
Chenopodium glaucum	3	2	46, 51
Chenopodium polyspermum	1	16	10, 11, 16, 18, 20, 22, 26, 29, 51, 53, 55, 59, 61, 62, 63, 71
Chenopodium rubrum	1	1	61
Chionodoxa forbesii	3	1	46
Chrysosplenium oppositifolium	1	3	14, 43, 44
Cichorium intybus	1	1	16
Circaea lutetiana	1	43	10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 23, 24, 26, 27, 28, 29, 31, 32, 33, 34, 35, 36, 38, 39, 40, 41, 42, 43, 44, 45, 47, 51, 53, 54, 56, 59, 61, 63, 64, 66, 67, 68
Cirsium arvense	1	26	11, 13, 14, 17, 18, 20, 21, 23, 24, 26, 31, 34, 36, 38, 41, 43, 54, 55, 56, 58, 61, 62, 63, 65, 67, 68
Cirsium oleraceum	1	24	11, 12, 13, 14, 18, 19, 31, 33, 34, 35, 36, 41, 43, 44, 45, 53, 54, 56, 59, 61, 65, 67, 68, 71
Cirsium palustre	1	8	10, 13, 14, 19, 34, 44, 45, 67
Cirsium vulgare	1	25	10, 11, 13, 14, 19, 20, 21, 25, 26, 29, 31, 33, 34, 38, 45, 54, 55, 59, 61, 62, 63, 64, 65, 67, 68
Cirsium x hybridum	1	1	13
Claytonia perfoliata	2	1	46
Clematis vitalba	1	1	53
Clerodendron trichotomum	3	2	42, 63
Conium maculatum	3	1	13
Convallaria majalis	1	6	11, 13, 17, 32, 34, 41
Convolvulus arvensis	1	2	51, 57
Conyza canadensis	2	18	10, 11, 13, 14, 19, 20, 40, 42, 46, 47, 54, 55, 58, 61, 62, 64, 66, 67
Conyza sumatrensis	2	5	17, 34, 42, 58, 62
Cornus sanguinea	1	12	12, 13, 18, 19, 26, 35, 36, 41, 42, 43, 45, 67
Cornus sericea	3	9	13, 19, 42, 43, 44, 45, 53, 57, 59
Coronopus didymus	2	9	13, 29, 38, 39, 46, 47, 59, 61, 64

Coronopus squamatus	1	3	20, 23, 61
Corylus avellana	1	32	11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 24, 25, 26, 27, 29, 30, 31, 32, 35, 36, 38, 40, 41, 43, 44, 45, 59, 61, 64, 66, 67, 68
Cotoneaster bullatus	3	1	65
Cotoneaster cf. affinis	3	1	42
Cotoneaster cf. amoenus	3	1	42
Cotoneaster cf. dielsianus	3	1	53
Cotoneaster cf. nitens	3	1	40
Cotoneaster divaricatus	3	1	65
Cotoneaster franchetii	3	1	65
Cotoneaster horizontalis	2	3	10, 39, 58
Cotoneaster moupinensis	3	3	18, 46, 53
Cotoneaster salicifolius	2	1	65
Crassula helmsii	3	2	23, 51
Crataegus monogyna	1	28	10, 11, 12, 13, 14, 17, 18, 21, 26, 27, 29, 30, 31, 32, 35, 36, 38, 41, 42, 43, 44, 45, 54, 59, 65, 66, 67, 68
Crepis biennis	3	3	43, 44, 53
Crepis capillaris	1	12	10, 11, 13, 14, 16, 29, 34, 51, 53, 54, 61, 64
Crepis paludosa	1	1	44
Cyclanthera brachystachya	3	1	51
Cymbalaria muralis	2	1	62
Cynanchum louisae	3	1	19
Cynosurus cristatus	1	5	13, 14, 21, 45, 59
Cyperus congestus	3	4	23, 42, 51, 53
Cyperus eragrostis	2	1	45
Dactylis glomerata	1	19	14, 16, 18, 19, 20, 24, 25, 26, 29, 31, 33, 34, 36, 38, 44, 45, 54, 56, 57
Dactylis polygama	5	27	10, 11, 14, 15, 16, 17, 18, 26, 27, 28, 29, 30, 32, 33, 34, 35, 36, 42, 43, 44, 54, 58, 59, 64, 66, 67, 68
Dactylorhiza fuchsii	6	4	12, 13, 59, 67
Dactylorhiza maculata	6	9	13, 14, 34, 44, 45, 57, 58, 59, 67
Dactylorhiza praetermissa	6	7	13, 14, 44, 45, 57, 59, 67
Datura stramonium	2	1	42
Daucus carota	1	5	43, 45, 46, 53, 66
Deschampsia cespitosa	1	18	11, 12, 14, 17, 18, 26, 29, 30, 34, 35, 36, 38, 43, 44, 55, 63, 67, 68
Deschampsia flexuosa	1	2	29, 67
Deutzia scabra	4	9	14, 17, 32, 36, 43, 59, 63, 64, 65
Dianthus carthusianorum	3	1	53
Digitalis purpurea	1	3	10, 20, 38
Digitaria sanguinalis	2	4	23, 42, 51, 55
Diospyros lotus	3	4	26, 43, 46, 53
Diospyros virginiana	3	1	46
Diplotaxis tenuifolia	1	1	61
Dipsacus fullonum	1	6	51, 53, 58, 59, 61, 71
Dipsacus pilosus	3	1	42
Doronicum pardalianches	3	2	47, 63
Dryopteris carthusiana	1	7	11, 12, 18, 36, 43, 45, 63
Dryopteris dilatata	1	13	11, 18, 19, 28, 32, 35, 41, 43, 44, 45, 54, 63, 66
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Duchesnea indica	2	31	10, 11, 13, 15, 17, 18, 19, 21, 23, 26, 27, 29, 33, 34, 38, 43, 45, 46, 54, 55, 56, 58, 59, 62, 63, 64, 65, 66, 67, 68, 71
Echinochloa crus-galli	2	5	20, 23, 42, 59, 63
Eleocharis palustris	1	1	13
Elymus caninus	3	3	31, 38, 51
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Epilobium ciliatum	2	10	10, 12, 14, 24, 26, 34, 45, 55, 61, 67

Epilobium collinum	1	3	13, 27, 53
Epilobium hirsutum	1	25	10, 11, 13, 14, 17, 18, 21, 24, 26, 29, 31, 34, 36, 38, 40, 42, 43, 44, 45, 46, 61, 62, 67, 68, 71
Epilobium montanum	1	13	11, 13, 18, 26, 27, 29, 34, 39, 54, 64, 65, 66, 67
Epilobium obscurum	1	6	23, 44, 45, 46, 51, 53
Epilobium parviflorum	1	24	10, 11, 13, 14, 18, 19, 23, 26, 34, 35, 39, 40, 42, 43, 45, 46, 51, 53, 54, 64, 65, 66, 67, 68
Epilobium roseum	1	10	13, 23, 25, 34, 40, 46, 54, 61, 64, 67
Epilobium tetragonum	1	25	11, 13, 14, 15, 16, 18, 20, 21, 22, 23, 26, 31, 33, 35, 36, 39, 41, 45, 46, 53, 61, 63, 64, 67, 71
Epipactis helleborine	1	30	11, 12, 13, 14, 15, 16, 18, 26, 27, 29, 31, 35, 38, 39, 42, 43, 44, 45, 47, 53, 54, 55, 57, 59, 61, 63, 65, 66, 67, 68
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Equisetum palustre	1	9	21, 34, 43, 44, 45, 57, 59, 63, 71
Erigeron karvinskyanus	2	1	65
Erodium cicutarium	1	1	71
Erophila verna	1	6	14, 38, 39, 46, 54, 63
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Euphorbia helioscopia	3	1	51
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Fagus sylvatica	1	35	10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 23, 24, 25, 26, 27, 29, 30, 31, 32, 33, 34, 35, 36, 38, 41, 43, 44, 45, 54, 56, 59, 64, 66, 67, 68
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Festuca brevipila	1	5	10, 13, 26, 54, 59
Festuca gigantea	1	8	13, 33, 41, 43, 44, 54, 67, 68
Festuca heterophylla	5	1	45
Festuca ovina	2	1	10
Festuca pratensis	1	2	20, 45
Festuca rubra	1	26	10, 13, 14, 16, 17, 18, 21, 24, 26, 27, 33, 34, 35, 43, 44, 45, 51, 53, 54, 55, 56, 59, 62, 64, 67, 71
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Filipendula ulmaria	1	14	11, 13, 14, 16, 33, 34, 36, 43, 44, 54, 57, 67, 68, 71
Foeniculum vulgare	3	1	51
Fragaria vesca	1	19	10, 11, 13, 14, 16, 20, 23, 26, 28, 33, 34, 35, 36, 53, 56, 59, 66, 67, 68
Fraxinus excelsior	1	42	10, 11, 12, 13, 14, 16, 17, 18, 19, 21, 23, 24, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 38, 39, 41, 42, 43, 44, 45, 51, 53, 54, 57, 59, 61, 64, 65, 66, 67, 68, 71
Fraxinus ornus	3	1	65
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Fumaria officinalis	3	1	51
Fumaria parviflora	3	1	51
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Geranium pusillum	1	9	13, 20, 31, 38, 46, 51, 66, 67, 71
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Helleborus foetidus	3	1	64
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Hypericum humifusum	1	2	42, 51
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Ilex aquifolium	1	33	10, 11, 12, 13, 14, 18, 19, 21, 24, 25, 26, 27, 28, 29, 30, 31, 32, 35, 38, 41, 42, 44, 45, 46, 54, 56, 59, 61, 63, 65, 66, 67, 68
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Listera ovata	1	6	11, 13, 43, 44, 67, 68
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Lycopus europaeus	1	16	11, 13, 14, 16, 17, 18, 20, 21, 23, 31, 34, 41, 43, 51, 63, 67
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Lythrum hyssopifolia	3	1	43
Lythrum salicaria	1	15	11, 13, 14, 16, 18, 21, 23, 31, 34, 42, 43, 44, 45, 61, 71
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Modiola caroliniana	3	1	51
Moehringia trinervia	1	26	10, 11, 12, 14, 15, 17, 18, 24, 28, 29, 32, 34, 35, 41, 43, 44, 45, 54, 56, 59, 61, 62, 63, 64, 67, 71
Montia minor	1	6	38, 39, 44, 46, 61, 63
Morus rubra	3	1	25
Mycelis muralis	1	1	27
Myosotis alpestris	2	1	18
Myosotis arvensis	1	8	19, 21, 26, 29, 46, 54, 61, 63
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Myosotis nemorosa	1	1	13
Myosotis ramosissima	1	5	23, 31, 53, 54, 61
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Persicaria minor	1	1	21
Persicaria mitis	1	1	23
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Pimpinella major	1	6	11, 13, 36, 54, 57, 64
Pimpinella saxifraga	1	1	13
Pinus strobus	3	1	65
Pinus sylvestris	1	1	65
Plantago coronopus	3	1	51
Plantago lanceolata	1	12	13, 14, 20, 21, 24, 26, 34, 51, 53, 61, 62, 66
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Polygonum aviculare	1	12	10, 18, 20, 24, 28, 31, 44, 47, 53, 61, 62, 64
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Populus canescens	1	16	11, 13, 17, 18, 21, 36, 41, 43, 44, 53, 54, 55, 57, 59, 61, 67
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Potentilla anserina	1	5	10, 11, 51, 67, 68
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Prunus cerasus	2	1	38
Prunus laurocerasus	2	30	11, 12, 14, 15, 16, 17, 18, 19, 24, 27, 28, 31, 33, 36, 38, 39, 40, 41, 42, 43, 44, 45, 54, 58, 59, 61, 63, 64, 67, 68
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Prunus padus	1	16	14, 18, 19, 20, 24, 35, 36, 38, 41, 44, 45, 54, 56, 59, 61, 63
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Rhinanthus minor	6	1	57
Rhus chinensis	3	1	47
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Ribes alpinum	4	8	14, 16, 19, 28, 36, 43, 59, 67
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Rorippa palustris	1	3	34, 61, 62
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Rosa sp.	1	6	15, 20, 27, 41, 43, 65
Rubus caesius	1	7	18, 31, 35, 43, 44, 45, 59
Rubus fruticosus	1	35	10, 11, 12, 13, 14, 16, 17, 18, 19, 21, 25, 26, 27, 29, 30, 31, 32, 35, 36, 38, 41, 43, 44, 45, 54, 55, 56, 59, 62, 63, 64, 66, 67, 68, 71
Rubus idaeus	1	2	21, 36
Rubus laciniatus	3	5	46, 51, 53, 54, 71
Rubus xanthocarpus	3	1	54
Rumex acetosa	1	16	11, 12, 18, 19, 28, 29, 32, 34, 38, 39, 51, 53, 54, 57, 59, 64
Rumex acetosella	1	2	29, 34
Rumex conglomeratus	1	8	11, 13, 26, 34, 43, 46, 57, 68

Rumex crispus	1	4	54, 58, 62, 63
Rumex hydrolapathum	1	2	13, 34
Rumex maritimus	1	1	61
Rumex obtusifolius	1	28	10, 12, 13, 14, 16, 18, 21, 23, 25, 31, 34, 38, 39, 41, 42, 43, 44, 54, 55, 56, 57, 59, 61, 62, 63, 64, 67, 68
Rumex sanguineus	1	36	10, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 23, 24, 26, 27, 28, 29, 30, 32, 33, 34, 35, 36, 38, 43, 45, 53, 54, 58, 59, 63, 64, 66, 67, 68, 71
Sagina apetala	1	17	10, 13, 14, 16, 19, 21, 23, 34, 46, 51, 53, 54, 55, 57, 58, 62, 63
Sagina procumbens	1	34	10, 11, 15, 17, 18, 19, 20, 22, 23, 24, 26, 28, 29, 31, 34, 35, 38, 39, 41, 43, 44, 45, 46, 51, 53, 54, 55, 58, 61, 62, 63, 67, 68, 71
Salix alba	1	5	22, 24, 42, 43, 62
Salix aurita	1	2	11, 68
Salix caprea	1	22	10, 11, 13, 14, 21, 24, 26, 31, 35, 43, 44, 45, 53, 54, 61, 62, 63, 64, 65, 66, 67, 68
Salix cinerea	1	2	11, 44
Salix x multinervis	1	7	13, 18, 41, 44, 62, 65, 68
Salix rubens	1	2	23, 65
Sambucus ebulus	3	1	42
Sambucus nigra	1	37	10, 11, 12, 13, 15, 16, 17, 18, 19, 21, 24, 25, 26, 27, 28, 29, 31, 32, 34, 35, 36, 38, 41, 42, 43, 44, 45, 54, 56, 58, 59, 61, 62, 64, 65, 67, 68
Sanicula europaea	1	1	44
Sanvitalia speciosa	3	1	58
Saponaria officinalis	3	1	53
Scirpus sylvaticus	1	4	13, 34, 45, 57
Scrophularia auriculata	1	2	18, 62
Scrophularia nodosa	1	26	10, 11, 12, 13, 18, 19, 21, 26, 27, 31, 33, 34, 35, 36, 43, 46, 51, 54, 55, 56, 62, 63, 64, 66, 67, 68
Scrophularia umbrosa	1	10	11, 13, 14, 17, 18, 21, 34, 43, 44, 57
Scutellaria galericulata	1	3	13, 14, 34
Sedum acre	1	1	13
Sedum album	3	2	39, 51
Sedum rupestre	2	1	27
Selinum carvifolia	1	1	44
Senecio inaequidens	2	12	12, 13, 38, 54, 58, 61, 62, 64, 65, 66, 67, 68
Senecio jacobaea	1	23	10, 11, 13, 14, 16, 17, 18, 20, 26, 29, 33, 34, 38, 43, 45, 53, 54, 57, 61, 62, 64, 67, 68
Senecio viscosus	1	1	34
Senecio vulgaris	1	23	11, 13, 19, 20, 23, 24, 25, 31, 38, 39, 42, 46, 51, 53, 54, 56, 57, 59, 61, 62, 63, 68, 71
Setaria pumila	3	2	46, 55
Sherardia arvensis	1	7	29, 34, 47, 53, 54, 55, 64
Silene dioica	1	39	10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 26, 27, 28, 29, 31, 32, 33, 34, 35, 36, 38, 41, 42, 43, 44, 45, 53, 54, 55, 56, 57, 59, 61, 63, 64, 65, 67, 68
Silybum marianum	3	1	64
Sinapis alba	2	1	63
Sinapis arvensis	1	3	11, 46, 63
Sisymbrium austriacum	3	1	51
Sisymbrium officinale	1	1	20
Solanum citrullifolium	3	1	51
Solanum dulcamara	1	5	26, 41, 42, 45, 46
Solanum nigrum	1	8	11, 20, 42, 58, 61, 63, 68, 71
Solidago canadensis	2	2	38, 68
Sonchus arvensis	1	4	21, 42, 54, 64
Sonchus asper	1	23	10, 11, 12, 13, 16, 17, 18, 19, 20, 26, 34, 39, 42, 45, 54, 55, 57, 59, 61, 62, 63, 66, 67

Sonchus oleraceus	1	24	11, 12, 13, 18, 20, 23, 24, 26, 36, 39, 42, 43, 46, 47, 53, 54, 55, 56, 61, 62, 63, 67, 68, 71
Sorbus aucuparia	1	30	10, 11, 12, 13, 18, 26, 27, 29, 30, 31, 33, 34, 35, 36, 39, 41, 42, 43, 44, 45, 53, 54, 55, 56, 59, 63, 64, 65, 67, 68
Sparganium erectum	1	2	21, 43
Spergularia rubra	1	1	61
Spiraea spec.	3	1	53
Sporobolus indicus	3	1	53
Stachys sylvatica	1	32	10, 11, 12, 14, 16, 17, 18, 19, 21, 26, 27, 28, 29, 31, 32, 34, 35, 36, 38, 41, 42, 43, 44, 45, 53, 54, 56, 59, 63, 66, 67, 68
Stellaria alsine	1	12	10, 13, 14, 18, 25, 29, 34, 36, 38, 44, 45, 46
Stellaria graminea	1	14	10, 13, 14, 18, 21, 29, 44, 45, 51, 54, 59, 62, 64, 71
Stellaria holostea	1	3	36, 38, 67
Stellaria media	1	28	10, 11, 15, 18, 19, 20, 22, 23, 26, 27, 28, 29, 38, 39, 41, 42, 43, 44, 45, 54, 55, 58, 61, 62, 63, 67, 68, 71
Stellaria pallida	1	1	68
Symphoricarpos albus	4	28	10, 11, 12, 13, 14, 16, 17, 18, 19, 21, 24, 25, 27, 31, 32, 34, 35, 36, 38, 41, 42, 43, 45, 54, 58, 59, 64, 68
Symphytum officinale	1	18	14, 18, 19, 21, 23, 34, 36, 38, 43, 44, 46, 51, 53, 56, 57, 59, 67, 68
Syringa vulgaris	4	3	21, 54, 59
Tanacetum vulgare	1	4	11, 14, 34, 62
Taraxacum officinale	1	43	10, 11, 12, 13, 15, 16, 17, 18, 19, 23, 24, 26, 27, 28, 29, 30, 31, 32, 35, 36, 38, 39, 40, 41, 42, 43, 44, 45, 47, 51, 53, 54, 55, 57, 58, 59, 61, 63, 65, 66, 67, 68, 71
Taxus baccata	1	37	10, 12, 13, 14, 15, 16, 17, 18, 19, 21, 22, 24, 25, 26, 27, 28, 30, 31, 32, 33, 34, 35, 36, 38, 41, 42, 43, 44, 47, 54, 56, 58, 59, 65, 66, 67, 68
Tellima grandiflora	4	7	12, 14, 15, 23, 33, 44, 63
Tetradium daniellii	3	1	53
Teucrium scorodonia	1	1	68
Thuja sp.	3	1	58
Tilia platyphyllos	1	24	10, 11, 12, 13, 14, 16, 17, 18, 19, 26, 30, 31, 35, 36, 38, 42, 43, 54, 56, 58, 59, 65, 67, 68
Trifolium dubium	1	15	13, 14, 18, 25, 29, 34, 38, 43, 44, 45, 54, 59, 61, 62, 67
Trifolium hybridum	1	1	20
Trifolium micranthum	1	6	13, 14, 21, 34, 61, 67
Trifolium pratense	1	9	18, 20, 42, 43, 44, 53, 59, 61, 64
Trifolium repens	1	31	10, 11, 13, 16, 18, 20, 21, 24, 27, 29, 31, 33, 38, 39, 40, 42, 44, 45, 46, 47, 51, 54, 55, 57, 59, 61, 62, 64, 67, 68, 71
Triticum sp.	3	3	27, 40, 53
Tussilago farfara	1	21	12, 13, 14, 16, 18, 21, 31, 32, 34, 41, 43, 53, 54, 55, 56, 58, 59, 62, 65, 66, 68
Typha latifolia	1	3	13, 44, 57
Ulex sp.	3	1	42
Ulmus glabra	1	19	10, 13, 18, 19, 24, 27, 29, 34, 35, 38, 41, 43, 44, 59, 61, 64, 65, 66, 67
Ulmus x hollandica	1	2	20, 68
Ulmus minor	1	1	34
Urtica dioica	1	42	10, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 23, 25, 26, 28, 29, 31, 32, 34, 35, 36, 38, 39, 40, 41, 42, 43, 44, 45, 54, 55, 56, 57, 58, 59, 61, 62, 63, 66, 67, 68, 71
Urtica urens	1	10	24, 38, 46, 51, 54, 57, 59, 61, 63, 71
Valeriana repens	1	13	11, 13, 14, 16, 17, 34, 36, 41, 42, 44, 56, 57, 61
Valerianella locusta	3	1	51

Verbascum densiflorum	1	1	29
Verbascum nigrum	1	3	20, 51, 61
Verbena bonariensis	3	4	14, 19, 41, 59
Verbena canadensis	3	1	51
Verbena officinalis	1	10	11, 13, 14, 31, 42, 46, 51, 61, 67, 71
Vernonia fasciculata	3	1	21
Veronica agrestis	1	8	18, 23, 38, 40, 47, 53, 55, 71
Veronica anagallis-aquatica	1	3	13, 34, 67
Veronica arvensis	1	10	14, 19, 34, 38, 51, 55, 58, 61, 62, 65
Veronica beccabunga	1	14	13, 16, 21, 23, 26, 34, 36, 42, 44, 45, 46, 53, 55, 57
Veronica chamaedrys	1	35	10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 24, 26, 27, 29, 34, 35, 38, 43, 44, 51, 53, 54, 55, 56, 57, 58, 59, 61, 62, 64, 66, 67, 68
Veronica filiformis	2	36	10, 11, 13, 14, 16, 17, 18, 19, 21, 23, 24, 25, 26, 27, 28, 29, 32, 34, 38, 39, 42, 44, 45, 46, 51, 53, 54, 55, 56, 57, 59, 61, 62, 64, 67, 71
Veronica hederifolia	1	27	10, 14, 17, 18, 19, 20, 22, 26, 28, 29, 30, 32, 35, 38, 40, 42, 44, 45, 46, 53, 54, 56, 58, 59, 61, 63, 64
Veronica peregrina	2	23	10, 16, 18, 19, 22, 23, 29, 31, 38, 39, 40, 42, 46, 47, 51, 53, 54, 57, 59, 61, 63, 67, 71
Veronica persica	2	18	10, 13, 18, 20, 23, 38, 39, 40, 42, 43, 44, 46, 53, 54, 57, 63, 67, 71
Veronica polita	1	2	23, 71
Veronica serpyllifolia	1	21	10, 11, 13, 14, 18, 21, 24, 26, 27, 29, 34, 35, 38, 39, 45, 51, 53, 61, 62, 67, 68
Viburnum opulus	1	14	10, 18, 25, 26, 27, 28, 36, 41, 43, 44, 45, 54, 56, 59
Viburnum plicatum	3	2	40, 59
Viburnum rhytidophylloides	3	2	10, 64
Vicia cracca	1	3	44, 61, 71
Vicia faba	3	2	13, 26
Vicia hirsuta	1	2	31, 43
Vicia sativa	1	3	43, 62, 66
Vicia sepium	1	4	12, 13, 43, 44
Vicia tetraspermum	1	2	53, 67
Vinca minor	1	9	12, 18, 19, 20, 24, 27, 41, 54, 59
Viola odorata	1	4	21, 26, 44, 58
Viola reichenbachiana	1	21	10, 11, 12, 18, 19, 21, 26, 29, 30, 31, 33, 35, 36, 38, 44, 45, 53, 54, 59, 63, 67
Viola riviniana	1	28	10, 11, 12, 13, 14, 15, 16, 17, 18, 20, 21, 26, 27, 28, 32, 34, 36, 38, 41, 43, 44, 56, 59, 61, 64, 65, 67, 68
Vulpia myuros	1	1	54

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The 'truly' indigenous flora

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Résumé. – La flore 'véritablement indigène' du Domaine du Jardin botanique national de Belgique. En première instance, la difficulté à déterminer le caractère indigène des espèces végétales est exposée ; ensuite les végétations et les espèces indigènes du Domaine sont traitées. Il s'y trouve plusieurs types de forêts de feuillus, ainsi que des prairies humides et des broussailles marécageuses, mais aussi des végétations pionnières, qui se rencontrent surtout dans les collections vivantes. Au total 357 espèces indigènes de plantes vasculaires ont été recensées, ce qui est élevé pour un terrain d'à peu près 1 km^2. 27 espèces rares (8%) ont été inventoriées, dont certaines pour la première fois. Trente pour cent des espèces rares poussent le long de sentiers ou dans des clairières dans des chênaies-charmaies, vingt pour cent dans les forêts marécageuses des aulnaies-fresnaies ; les autres espèces rares croissent sur des murs, dans des sites pionniers, dans des prairies de fauche, et en moindre mesure dans des zones de pelouses rases.

Samenvatting. – De 'werkelijk' inheemse flora van de Nationale Plantentuin van België. Deze bijdrage belicht de moeilijkheid voor het bepalen of soorten al dan niet oorspronkelijk als inheems aanwezig zijn, waarna de inheemse vegetaties en plantensoorten in het Domein besproken worden. Er komen verschillende types loofbossen voor, evenals natte graslanden en moerassige ruigtes, maar ook pioniersvegetaties die vooral in de collecties voorkomen. In totaal werden er 357 inheemse soorten vaatplanten gevonden, wat een hoog aantal is voor een gebied van ongeveer 1 km^2. Daarvan zijn 27 soorten (8%) zeldzaam, en sommige soorten werden in deze inventarisatie voor het eerst aangetroffen. Dertig procent van de zeldzame soorten komt voor langs paden en in open plekken in eiken-haagbeuken-bossen, twintig procent in moerassige elzen-essenbossen, en de overige op muren, in pioniersvegetaties, in hooiweiden, en in mindere mate in korte gazons.

Introduction

This contribution discusses the indigenous vegetation as well as the 'truly' indigenous plant species. This includes the species placed in category 1 as defined in Ronse (2011a, this volume, p. 33). These are the plants that are present in the Domain from a long time ago. It excludes the 'stinsen' plants and the other introduced species (Ronse 2011b), as well as the indigenous species that have been planted in the collections and that have spread outside the plant beds (collection escapes, Ronse 2011c). However, archaeophytes are included.

It is not always easy to find out whether a species is truly indigenous or not. It demands knowledge of the previous history of each species, and this is often lacking. Old accessions that predate 1988 with cultivation annotations are not available in the database of collection plants LIVCOL.

An example of the complexity of the classification of plants into categories is the indigenous orchid species. Some species were originally present in the Domain, but they disappeared due to the use of lawnmowers and the ground work and excavations done for the laying out of the herbetum and the fruticetum

during the sixties and seventies. Several species were planted in the seventies, using plants of non-local origin. Many of those plants have grown well and propagated, especially since some of the grassland has been managed like meadows. Those species are locally indigenous, but the plants originate from a non-local source. That is why they have been classified in category 6, as deliberate indigenous introductions, and not as truly indigenous plants. However, plants of some of those species (*Dactylorhiza* spp.) have been found recently outside the Domain in roadsides less than five kilometres away (pers. obs. AR). So it is possible that some of the plants in the Domain originate from a local indigenous source, or conversely that those plants in the surroundings originate from the Domain. Without genetic studies this cannot be ascertained.

This contribution starts with a short discussion of the species richness of indigenous species in the Domain, followed by a description of the different types of (semi-) natural vegetation; for each type some of the typical or specific indigenous species are given. In the third part the rare species that are truly indigenous (not collection escapes) are individually discussed.

Species richness of indigenous species

In total 357 'truly' indigenous species have been observed in the Domain, these are taxa that are supposed to have reached the Domain spontaneously, without any introduction (see table 1 in Ronse 2011a). This is a very high number for an area of about 1 km². The species-area relation is known to be a power curve, and for vascular plants in Northern Belgium it has been computed by Stieperaere (1979). For an area of 1 km² a standard number of 119 plants has been calculated, with omission of adventicious plants, but the author warns that this probably gives underestimated values. Our result of 357 species is exactly three times as high as the predicted value, and is high anyway.

We can also compare the number of indigenous species in the Domain with data from the Plant Atlas of Flanders (Van Landuyt, Vanhecke & Hoste *in* Van Landuyt *et al.* 2006). This gives numbers between 33 and 511 indigenous species per grid square of 16 km² for the entirety of Flanders, and up to 45 archaeophytes additionally. The grid square containing the Domain of the Botanic Garden (D4.55) has, according to the Atlas, between 301 and 400 indigenous species, and between 21 and 30 archaeophytes. This gives a sum of between 322 and 430 species for the larger square of 16 km² that can be compared with the 357 species found in the Domain alone, in an area that is sixteen times smaller! It should be noted that part of the data used in the Atlas include (our first) mapping results of 2002, that have been further elaborated for this study.

Vegetation types and their most typical species

Since nearly half the surface area of the Domain is wooded, many forest species occur. The forests that are found are oak-hornbeam forest, beech forest, and alder-ash woodland. The most frequently occurring (indigenous) tree and shrub species are (in declining order of frequency): *Acer pseudoplatanus*, *Fraxinus excelsior*, *Carpinus betulus*, *Quercus robur*, *Sambucus nigra*, *Fagus sylvatica*, *Corylus avellana*, *Taxus baccata*, *Ilex aquifolium*, *Sorbus aucuparia*, *Crataegus monogyna*, *Castanea sativa*, *Tilia platyphyllos*, *Salix caprea*, *Ulmus glabra*, *Prunus padus*, *Cornus sanguinea*, *Prunus avium*, and *Alnus glutinosa*. Each of those species grows in at least ten sectors. Other species have been found less frequently: *Betula pendula*, *Salix ×multinervis*, *Salix alba*, *Salix aurita*, *Salix cinerea*, *Salix ×rubens*, *Acer campestre*, *Juglans regia*, *Euonymus europaeus*, *Populus tremula*, *Ulmus minor* and *Ulmus ×hollandica*. Note that some of these species may not be locally indigenous in the region, such as *Juglans regia*, *Taxus baccata* and *Ulmus ×hollandica*.

In the herbaceous layer and the lower shrub layer a lot of species can be found that are typical for the deciduous forests of the loamy region, such as *Carex sylvatica*, *C. remota*, *Brachypodium sylvaticum*, *Circaea lutetiana*,

Deschampsia cespitosa, *Dryopteris carthusiana*, *Festuca gigantea*, *Fragaria vesca*, *Geum urbanum*, *Luzula pilosa*, *Lysimachia nemorum*, *Moehringia trinervia*, *Myosotis sylvatica*, *Poa nemoralis*, *Polygonatum multiflorum*, *Potentilla sterilis*, *Primula elatior*, *Ranunculus auricomus*, *Ribes rubrum*, *R. uva-crispa*, *Rumex sanguinea*, *Vinca minor*, *Viola reichenbachiana* and *V. riviniana*. Some of these are ancient forest plants (Hermy *et al.* 1999), such as *Adoxa moschatellina*, *Ranunculus auricomus*, *Brachypodium sylvaticum*, and *Festuca gigantea*.

Along forest paths and open spaces we find *Cardamine flexuosa*, *Digitalis purpurea*, *Epilobium angustifolium* and several other *Epilobium* species (including *E. montanum*), and also *Humulus lupulus*, *Ornithogalum umbellatum* and *Persicaria hydropiper*. Some species indicate a basic soil, such as *Clematis vitalba*, that has been observed in one sector. Some other species conversely indicate a rather acidic soil: *Convallaria majalis*, *Deschampsia flexuosa*, *Holcus mollis*, *Milium effusum*, *Oxalis acetosella*. The latter species only occurs in a limited number of sectors, as discussed in Ronse (2011a).

In spring, many flowering plants can be found in the woods, such as *Adoxa moschatellina*, *Allium ursinum*, *Anemone nemorosa*, *Arum maculatum* and *Ranunculus ficaria*. *Allium ursinum* is rather common in Flanders, and occurs with large populations in many sectors.

In the Domain there is an alder-ash woodland (*Carici remotae-Fraxinetum*), this is one of the rarest plant communities of Europe, which mostly consists of small forest fragments in areas containing springs or along the upper course of rivers. This marshy wood is situated in sectors 43 and 44 (see the map on p. 66), in the western part of the Domain, and contains a lot of places with seepage water. At those places tufa can be found; this small, porous limestone is formed by precipitation of calcareous minerals from the water. Some specific vascular plant species grow there, such as the rare *Campanula trachelium*, as well as *Chrysosplenium oppositifolium*, *Cardamine amara* and *Paris quadrifolia* and *Carex remota*. In this area *Berula erecta* also occurs, together with the much resembling *Apium nodiflorum*, which also grows along streams in some other sectors. *Listera ovata* has also been observed in this marshy woodland; it is present in other localities in the Domain as well. It grows along the castle lane in the grassy vegetation under the majestic beech trees, as well as in the marshy woods of sectors 43 and 44. It also grows on the island in the castle lake, not far from the place where a now disappeared population of more than 50 specimens was recorded in 1977 by L. Vanhecke (pers. comm.). This inconspicuous orchid is rather common in Flanders, especially on loamy soils (Meeuwis *in* Van Landuyt *et al.* 2006).

Within the Domain wet grassland and tall herb fen occur in different localities. Some of the more frequent species in these are: *Caltha palustris*, *Apium nodiflorum*, *Cirsium oleraceum*, *Eleocharis palustris*, *Epilobium hirsutum*, *Eupatorium cannabinum*, *Filipendula ulmaria*, *Galium palustre* and the very similar but rarer *G. uliginosum*, *Glyceria fluitans*, *G. maxima*, *G. declinata*, *G. notata*, *Hypericum dubium*, *H. tetrapterum*, *Iris pseudacorus*, *Juncus articulatus*, *J. conglomeratus*, *J. inflexus*, *Lotus pedunculatus*, *Lycopus europaeus*, *Myosotis scorpioides*, *M. laxa*, *Nasturtium microphyllum*, *N. officinale*, *Persicaria bistorta*, *Petasites hybridus*, *Poa palustris*, *Scirpus sylvaticus*, *Scrophularia auriculata*, *S. umbrosa*, *Scutellaria galericulata*, *Solanum dulcamara*, *Sparganium erectum*, *Stellaria alsine*, *Typha latifolia*, and *Veronica anagallis-aquatica* subsp. *anagallis-aquatica*. It is remarkable that both *Glyceria notata* and *G. declinata* grow in the Domain, while *G. notata* is only rarely recorded from Northwest Brabant.

Locally there are also vegetations of tall sedges, with *Carex acuta*, *C. acutiformis*, *C. disticha*, *C. flacca*, *C. pseudocyperus* and *C. riparia*.

The grasslands on moderately wet and mesotrophic soils are mostly Sub-Atlantic lowland hay meadows, with *Arrhenatherum elatius* as dominant grass species. In these grasslands many other species thrive: *Anthoxanthum odo-*

ratum, *Centaurea jacea*, *Cerastium fontanum*, *Cichorium intybus*, *Crepis capillaris*, *Daucus carota*, *Geranium dissectum*, *G. molle*, *G. pusillum*, *Hypericum perforatum*, *Hypochaeris radicata*, *Lathyrus pratense*, *Leucanthemum vulgare*, *Pimpinella major*, *P. saxifraga*, *Plantago lanceolata*, *Rumex acetosa*, *Stellaria graminea*, *Veronica serpyllifolia*, *Vicia cracca*, *V. hirsuta*, *V. tetraspermum*. *Pimpinella saxifraga* has been found in only one sector in the Domain; in the surrounding areas of Northwest Brabant it is much rarer than *Pimpinella major*. *Cichorium intybus* has also been found in only one sector. On a few places *Cynosurus cristatus* was found as well. This grass is normally found in grazed meadows; in Meise there is no grazing except by the numerous geese that reside in the Domain. For tens of years these were mainly greylag geese (*Anser anser*), but nowadays they include a many Canada geese (*Branta canadensis*) and some Egyptian geese (*Alopochen aegyptiaca*) and barnacle geese (*Branta leucopsis*). Some other plant species that benefit from the grazing include *Centaurium erythraea*, *Rumex maritimus* and *Isolepis setacea*.

The latter type of vegetation contains pioneer vegetation, which occur on places with open or ruderal vegetations. These are places where the soil is turned over and the weeds are hacked or chopped, where the soil is trodden or ridden on, or where other kinds of disturbance occur. Some examples of pioneer species present at such locations are: *Anagallis arvensis*, *Centaurium erythraea*, *Cerastium glomeratum*, *Chenopodium polyspermum*, *C. rubrum*, *Coronopus didymus*, *C. squamatus*, *Diplotaxis tenuifolia*, *Erophila verna*, *Euphorbia peplus*, *Fallopia convolvulus*, *Hordeum murinum*, *Isolepis setacea*, *Lactuca serriola*, *Lamium amplexicaule*, *Montia minor*, *Rumex maritimus*, *Sedum acre* and *Spergularia rubra*.

Rare indigenous species

The rarity of plant species in Flanders has been expressed by their KFK value as a measure of the number of localities where they still occur (Van Landuyt *et al.* 2006); this KFK value varies from 0 to 10. Rare species have a KFK value between 1 and 4. Plants with KFK 1 are defined as extremely rare, KFK 2 as very rare, KFK 3 as rare and KFK 4 as rather rare. In the Domain 29 'truly' indigenous plant species (category 1) from those four KFK classes have been recorded, which represents 8 % of the species from this category; five of them are ferns. The 29 species are listed in table 1, and the distribution of rare indigenous species within the Domain is shown in figure 1. This map shows that the sectors with more than three indigenous rare species consist of the forest swamp (sector 43 and 44), as well as a cluster located close to the castle (sectors 11, 13, 14, 18, 34, 59 and 68) and a cluster near the herbetum (51, 53, 54), and sectors 29 and 38. Most of these sectors also have a high total number of plant species.

Table 1. Rare indigenous plant species and their degree of rarity (KFK class).)

Name	KFK
Polystichum setiferum	1
Asplenium adiantum-nigrum	2
Bromus inermis	2
Festuca brevipila	2
Fumaria capreolata	2
Hypericum hirsutum	2
Parietaria officinalis	2
Polystichum aculeatum	2
Carex pendula	3
Impatiens noli-tangere	3
Selinum carvifolia	3
Stellaria pallida	3
Trifolium micranthum	3
Verbascum densiflorum	3
Veronica polita	3
Amaranthus blitum	4
Asplenium scolopendrium	4
Asplenium trichomanes	4
Campanula trachelium	4
Carex flacca	4
Carex spicata	4
Centaurium pulchellum	4
Chrysosplenium oppositifolium	4
Crepis paludosa	4
Epilobium obscurum	4
Hieracium lachenalii	4
Mespilus germanica	4
Sanicula europaea	4
Sherardia arvensis	4

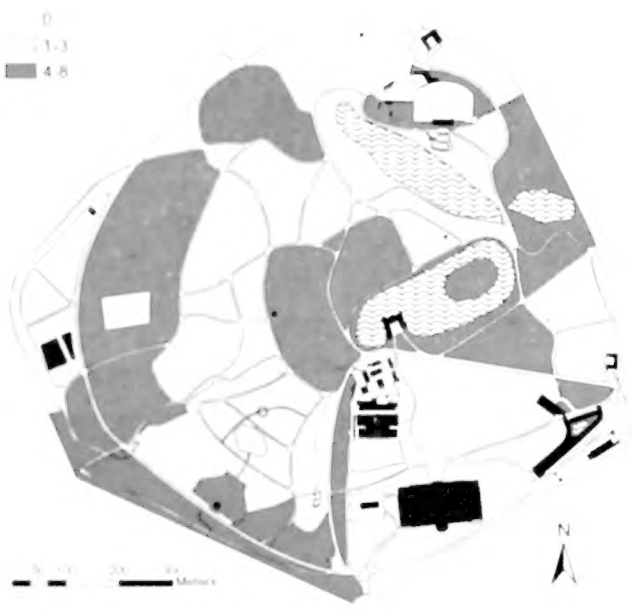


Figure 1. Distribution of rare indigenous species per sector in the Domain of the National Botanic Garden.

• *Extremely rare species (KFK 1)*

Only one extremely rare 'truly' indigenous species has been found, namely the fern *Polystichum setiferum*. One plant was found along the Amelvonnebeek, in the swampy woodland of sector 43. This species of moist fen valley woodlands is only known from three other localities in Flanders (Viane *in* Van Landuyt *et al.* 2006), so this is a new locality.

• *Very rare species* (KFK 2)

Seven very rare species were found, of which one in the central courtyard of the herbarium building, namely *Asplenium adiantum-nigrum* (Hoste & Geerinck 2011). This fern that grows on walls has also been recorded in 2010 from several kilometres away outside the Domain (pers. obs. AR).

Another very rare species is *Bromus inermis*, a grass found in one place at the foot of trees with low branches, where the grass is not frequently mown. *Festuca brevipila* is another very rare grass; it has been found in five localities in the Domain, in wood lawn or at the foot of trees, on dry places in rather open vegetation, mostly on a slope. This fescue has often been sown in roadsides in Flanders.

Fumaria capreolata has been observed in the Domain in two localities, including one in the vicinity of the herbetum, where it is cultivated. In this locality the species is considered as a collection escape. There is also a single record of one plant from sector 18, at the other side and on the outskirts of the Domain. This plant could be regarded as truly indigenous, as this species occurs in Flanders mainly in the loamy region (Ronse *in* Van Landuyt *et al.* 2006), and several localities are known from Meise and other neighbouring communes.

A very rare species that has been recorded only once from the Domain is *Hypericum hirsutum*, an ancient forest species that grows on nutrient poor soils, in glades and forest clearings and along forest paths (Ronse *in* Van Landuyt *et al.* 2006). This species has a preference for large forests of at least 10 ha and preferably more than 80 ha (Tack *et al.* 1993). In the Domain it has been found in a small group of trees in sector 55 in 2002, but it has not been observed since then.

Parietaria officinalis is a plant that grows on walls and rocks. It has been found on the walls of a cold greenhouse in sector 23, as well as in the herbetum and in a neighbouring sector. The species can also be a collection escape in the latter two localities, as it is cultivated in the herbetum and in the medicinal garden.

The last very rare species is *Polystichum aculeatum*, a fern that is related to *Polystichum setiferum*. One plant of it has been found growing on the top of an old ice cave in sector 68, in the vicinity of the main entrance of the Domain, under *Taxus baccata*. Most of the localities of this species in Flanders are situated in the loamy part of the province of Vlaams-Brabant. It is an ancient forest species that usually grows in hollow roads and on old walls (Viane *in* Van Landuyt *et al.* 2006).

• *Rare species* (KFK 3)

Seven indigenous species that were found in the Domain are rare in Flanders (KFK3), among them the sedge *Carex pendula*, which has been observed in six sectors distributed over all parts of the Domain. It stands in or at the edge of woodland, mostly in moist places. It is considered to be an ancient forest species (Hermy *et al.* 1999), and grows in seepage zones in woodland on loamy soils. In the surrounding region

of northwestern Vlaams-Brabant an increase of this species has been observed during the last decade (pers. obs. AR).

Impatiens noli-tangere has been found in three wooded sectors at the beginning of the mapping period, but it has not been observed in the Domain since then. There are also former records of this species in the Domain by G. Bruynseels in 1978.

Only a few plants of *Selinum carvifolia* have been found in sedge vegetation in sector 44, along a rivulet flowing from sector 43. In Flanders this species mainly occurs in valleys in the regions of Hageland and Haspengouw, in nutrient poor, humid to moist meadows and forest edges, on sites with seepage of base-rich water (Van Landuyt *in* Van Landuyt *et al.* 2006).

Stellaria pallida has been found in one locality along the castle lane. It is, however, possible that this inconspicuous species also occurs elsewhere in the Domain. In Flanders it occurs mainly along the coast, but it is increasingly being recorded from inland localities along roadsides (Van Landuyt *in* Van Landuyt *et al.* 2006).

Trifolium micranthum has been recorded from six sectors (13, 14, 21, 34, 61 and 67) in the vicinity of the castle, the plant palace, and the orangery lake. This small yellow flowering clover has been collected for the first time in the Domain in 1985 by F. De Raeve ('massaal in enkele gazons'; herb. BR). It grows on humid, more or less nutrient rich soils. The bulk of its localities in Flanders are formed by intensively mown lawns, including numerous (Commonwealth) war cemeteries in the region around Ypres (Van Landuyt *et al.* 2004). It is probably often spread by lawn mowers, and this is what may have happened in the Domain too.

Verbascum densiflorum flowered on a disturbed place in the middle of a lawn in 2008. This species occurs naturally in the region, but it is also cultivated in the herbetum. So either this species grows as a truly indigenous plant in the Domain or it is a collection escape.

Veronica polita has been found in sectors 23 and 71, where plants are propagated for the collections. The species had already been recorded from the orangery garden (sector 22) by Jongepier and Robbrecht (1986). *V. polita* is a pioneer species found in cultivated plots like fields and kitchen gardens.

• *Rather rare species* (KFK 4)

Fourteen rather rare indigenous plants have been found in the Domain.

Amaranthus blitum has been found in ruderal places in seven sectors within the Domain. This species is typically a weed in arable land, and it is increasingly found in Flanders, possibly due to global warming.

Asplenium scolopendrium grows in the Domain in (semi-) natural localities in sectors 43 and 18, where the species grows on steep river banks of the Maalbeek, in natural vegetation of (swampy) deciduous woodland. It has been found in similar conditions in the region, e.g. along the Kleine Buisbeek in Humbeek (pers. obs. AR 2006). Within the Domain this species has also been planted in one sector, where it is considered as a deliberate introduction (Ronse 2011b), and it has also been found in the central courtyard of the herbarium building.

Asplenium trichomanes is another rare fern that has been found in the Domain in the central courtyard of the herbarium building (Hoste & Geerinck 2011).

Campanula trachelium has been observed once in the Domain along a watercourse in the swampy woodland of Wild Meise. This species thrives in moist deciduous forests, usually on loamy soils, and is considered to be an 'ancient forest species' (Hermy *et al.* 1999). It needs sufficient light and suffers from high competition by taller species. This may have caused its disappearance from the Domain, since it has not been seen in 2009 in spite of a targeted search for it. A global decline of this species in Flanders has been reported, probably often due to competing taller vegetation and a decrease of the practice of coppicing (Van den Bremt *in* Van Landuyt *et al.* 2006).

Two rather rare sedge species have also been found in the Domain, namely *Carex flacca* and *Carex spicata*. The first one grows in swampy tall vegetation in sector 44, while the

latter was observed in two localities under trees along a lawn.

The pretty pink flowers of *Centaurium pulchellum* perk up open spaces around the castle lake. It is a pioneer species from rather sandy and calcareous soils.

Chrysosplenium oppositifolium is a typical plant of alder-ash woodland and seepage places in woodland. It is also an ancient forest species. It grows along a rivulet that flows from sector 43 to sector 44 in Wild Meise, and it has also been found in another sector close to the castle, along the Amelvonnebeek.

A single plant of *Crepis paludosa* has been found in 2003 in the swampy woodland of sector 43; it has not been found again afterwards. The disappearance of this species is probably due to the surrounding vegetation having grown too tall, a trend that probably also explains the decline of *Campanula trachelium*. *Crepis paludosa* occurs on loamy soils with seepage, in Calthion vegetation as well as in transition stages to moist woodland (Zwaenepoel *in* Van Landuyt *et al.* 2006).

Epilobium obscurum was observed in six sectors in the Domain (23, 44, 45, 46, 51 and 53). Some of these are nurseries and collections, but other sectors contain (semi-) natural vegetation. This is a species that grows on humid to moist soils in light shade. Plants are easily mistaken for *E. tetragonum*, a more common species; it might occur more frequently than recorded.

Hieracium lachenalii has been recorded in nine sectors within the Domain. All localities are situated under trees, on patches where several different boletes and other rare mushrooms have been found (Van de Kerckhove 2011). This Asteraceae has shown a very strong decline in Flanders, due to eutrophication and increased competition from taller vegetation (Zwaenepoel *in* Van Landuyt *et al.* 2006). This is also a species with a clear preference for large forests (Tack *et al.* 1993).

Mespilus germanica has been recorded from three sectors (11, 35 and 43) with (semi-) natural forest vegetation. It has been introduced into Belgium from the Mediterranean area for its fruit in the Roman era.

Sanicula europaea grows at one location in the Domain, in sector 44 along the perimeter road. It is an indicator of ancient forests, where it usually grows in forest edges or along paths in rather shaded patches.

Sherardia arvensis has been found in seven sectors. An increase of this thermophilic species within the Domain has been observed between 2002 and 2010. Large populations of it have been observed a few kilometres to the south of the Domain, on the southern slopes of the interchange of the A12 highway with the Ring around Brussels (R0) in Strombeek-Bever (pers. obs. AR). This pioneer species formerly grew mainly as weed in arable fields on loam, but today it is more often recorded from field edges or coastal dunes, or from road verges (as in Strombeek-Bever). Within the Domain it mainly grows in or at the border of short lawns.

Conclusion

In the Domain of the National Botanic Garden of Belgium a total of 357 species of 'truly' indigenous vascular plants (including archaeophytes) have been observed between 2002 and 2010. This is a high number, compared to the biodiversity of other similar areas. As half of the area of the Domain is wooded, several deciduous forest types are present that are typical for the loamy region in Flanders, such as oak-hornbeam forests, beech forests, and alder-ash woodland. All types of woodland contain species-rich shrub layers and herbaceous layers, some of these with species typical for ancient forests. However, the swampy alder-ash woodland is especially worth mentioning, as it is nationally and internationally rare, and contains many rare species. Other vegetation types that occur in the Domain are wet grassland and tall herb fen, Sub-Atlantic lowland hay meadow, and pioneer vegetations of disturbed places. In total, 29 rare indigenous vascular plant species have been recorded, including the extremely rare *Polystichum setiferum*, which is reported for the first time from the Domain. About 30 % of the rare species grow on clearings and at the edges of oak-hornbeam woodland, and nearly 20 % in the swampy alder-ash woodland. Oth-

er habitats where rare plants can be found are walls, pioneer vegetation, hay meadows, and to a lesser extent short-cut lawns.

References

Hermy M., Honnay O., Firbank L., Grashof-Bokdam C. & Lawesson J.E. (1999) – An ecological comparison between ancient and other forest plant species of Europe, and the implication for forest conservation. *Biological Conservation* **91**: 9-22.

Hoste I. & Geerinck D. (2011) – The vegetation of the enclosed courtyard at the herbarium building. *Scripta Bot. Belg.* **47**: 145-153

Jongepier J.W. & Robbrecht E. (1986) – Een 'nieuwe' vondst van Euphorbia humifusa in België. *I.F.B.L. Driemaandelijks contactblad* **4 (2)**: 16-19.

Ronse A. (2011a) – The wild flora of the Botanic Garden: an introduction. *Scripta Bot. Belg.* **47**: 27-58

Ronse A. (2011b) – Stinsen plants and other deliberate introductions in the (semi-) natural zones of the Botanic Garden. *Scripta Bot. Belg.* **47**: 67-75

Ronse A. (2011c) – 'Botanic garden escapes' from the living collections at the Botanic Garden. *Scripta Bot. Belg.* **47**: 89-111

Stieperaere H. (1979) – The species-area relation of the Belgian flora of vascular plants, and its use for evaluation. *Bull. Soc. Roy. Bot. Belg.* **112**: 193-200.

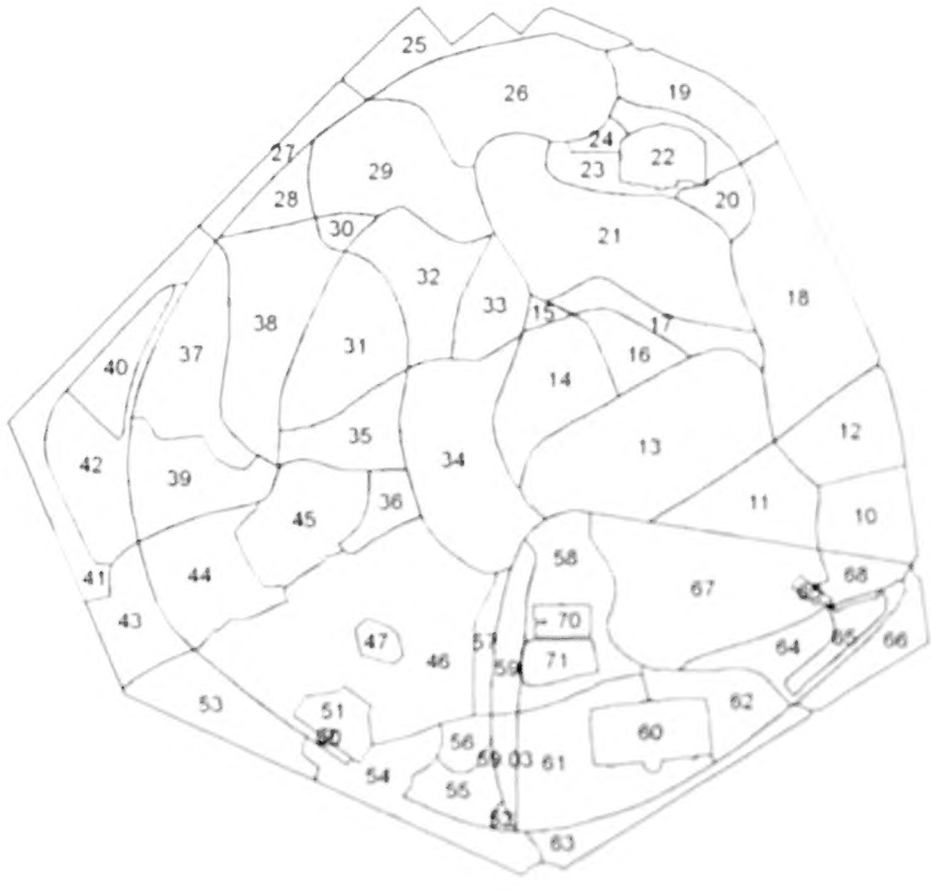
Tack G., Van den Bremt P. & Hermy M. (1993) – Bossen van Vlaanderen: een historische ecologie. Leuven, Davidsfonds.

Van de Kerckhove O. (2011) – Red List ectomycorrhizal fungi and their dependence on management. *Scripta Bot. Belg.* **47**: 181-191

Van Landuyt W., Vercruysse W. & Zwaenepoel A. (2004) – Trifolium filiforme in Flanders Fields. Verspreiding en staanplaatsen op militaire begraafplaatsen in de omgeving van Ieper (West-Vlaanderen). *Dumortiera* **82**: 10-15.

Van Landuyt W., Hoste I., Vanhecke L., Van den Bremt P., Vercruysse W. & De Beer D. (2006) – Atlas van de flora van Vlaanderen en het Brussels Gewest. Brussel & Meise, INBO, Nationale Plantentuin van België & Flo.Wer.

Annex. Map of the Domain of the National Botanic Garden of Belgium with location of the sectors.



Scripta Botanica Belgica **47**: 67-75 (2011)

Stinsen plants and other deliberate introductions in the (semi-) natural zones of the Botanic Garden

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Scripta Bot. Belg. **47**: I. Hoste (ed.), The spontaneous flora of the National Botanic Garden of Belgium (Domein van Bouchout, Meise)

Résumé. – Plantes castrales et autres introductions délibérées dans les zones semi-naturelles du Jardin botanique national. Cette contribution discute les plantes introduites délibérément dans le Domaine en dehors des collections, notamment les plantes castrales, mais aussi des introductions plus récentes. Les périodes d'avant et après 1938 ont été traitées séparément, date à laquelle le Jardin botanique a été aménagé dans le Domaine. Dans une grande partie des cas l'introduction des espèces n'a pas été documentée. Au total 25 espèces introduites délibérément ont été retrouvées, dont 8 espèces qui sont probablement des plantes castrales, et 9 espèces introduites après 1938. Un nombre important d'espèces ligneuses a été planté lors de l'aménagement des jardins à l'anglaise. Près de la moitié des espèces introduites sont des espèces rares.

Samenvatting. – Stinsenplanten en andere bewuste introducties in de Nationale Plantentuin. Deze bijdrage behandelt planten die opzettelijk geïntroduceerd werden in het Domein buiten de collecties, zoals de zogenaamde stinsenplanten, maar ook recentere introducties. Er wordt een onderscheid gemaakt tussen de periodes voor en na 1938, wanneer de Plantentuin in het Domein werd ondergebracht. In talrijke gevallen is de introductie van de soorten niet gedocumenteerd. In totaal werden 25 soorten van opzettelijke introducties aangetroffen, waaronder 8 soorten die vermoedelijk stinsenplanten zijn, en 9 soorten die na 1938 werden aangeplant. Heel wat houtachtige soorten werden aangeplant bij de aanleg van Engelse landschapstuinen tijdens de 19de eeuw. Ongeveer de helft van de geïntroduceerde soorten zijn zeldzame soorten.

Introduction

So-called 'stinsen plants' are species that have been deliberately planted, and that have subsequently become naturalized in an area where they don't grow naturally, according to the definition of Bakker & Boeve (1985). These plants have mostly been planted in the 18th or 19th century in parks and castle estates because of their ornamental value. This is a Dutch term and concept, that has no current counterpart in English, so we have chosen here to use the original word as such.

Sometimes the term 'stinsen plants' is also used for indigenous species that have been introduced locally. Without molecular genetic techniques, however, it is impossible to find out if this is the case, so we have only taken into account non-indigenous species in the Domain. For example, *Allium ursinum*, *Arum maculatum* and *Anemone nemorosa* are not considered as stinsen plants in the Botanic Garden, even if they are in Friesland or some other parts of The Netherlands, where they do not occur naturally. Indeed, in the region surrounding the Domain the three species are found growing naturally. Other species known as stinsen plants that are considered here to be truly indigenous species include *Lamium galeobdolon* subsp. *montanum*, *Primula elatior* and *Potentilla sterilis*.

Beside stinsen plants, other deliberately introduced plants are present in the (semi-) natural areas of the Botanic Garden in Meise. These

are 20th-century introductions, mostly from between 1970 and 1980, when the Botanic Garden was laid out in the Domain of Bouchout. Like stinsen plants, some of these species don't occur naturally in the region, but they have not been introduced during the same period. On the other hand, however, truly indigenous species have also been (re)introduced in the Domain in the 20th century. We can call all these more recent deliberate introductions 'landscaping plants'.

It is not always easy to find out during which period a particular species has been introduced, especially for the years before the founding of the Botanic Garden in 1939. Some of the introduced species have been planted at the beginning of the 19th century, when the English style landscape of the Domain was laid out (Ronse & Vidts 2011). Maybe some other species were introduced at some other moment in the two former castle estates, but this has not been documented.

Sometimes a species is found both within the Domain and in surrounding gardens or in other estates only a few kilometres away. Then the question arises as to whether these plants have been deliberately introduced in the Domain and have subsequently spread into the surroundings, or whether they have originated in the Domain from cultivated plants in nearby gardens. To answer this question the local and regional distribution of the species were checked, as well as the observation periods outside and within the Domain, but the conclusion often remains hypothetical.

In this contribution we distinguish between species that have been introduced before and after 1938, the year after which the Botanic Garden was gradually moved from Brussels to the Domain. For each species the original distribution and occurrence in Flanders are mentioned, in so far as this is known, followed by a brief discussion of its occurrence in the Domain.

Species introduced before 1938

Woody species used in English landscape gardens

Several trees and shrubs in the wooded parts of the Domain have been introduced during the 19th century and have become naturalized. They have been planted during the transformation of (parts of) the castle estates of Meise and Bouchout into English style landscape gardens (Ronse & Vidts 2011). These are *Acer platanoides*, *Deutzia scabra*, *Philadelphus coronarius*, *Ribes alpinum* and *Symphoricarpos albus*.

Acer platanoides, native to mountainous areas in Central Europe, has a distribution range that reaches as far west as the Ardennes, in southern Belgium. In Flanders it has naturalized as a result of spontaneous seeding in old parks and plantations. It has greatly increased during recent decades, and has become rather common, especially in the loamy region (F. Verloove, *in* Van Landuyt *et al.* 2006). In the Domain the species has been recorded from 31 sectors, this is about 70% of all sectors with at least some wooded parts.

The shrubs of genera *Deutzia* and *Philadelphus* (both Hydrangeaceae) are often planted in parks. Many species and varieties are used; usually they belong to the species *Deutzia scabra* and *Philadelphus coronarius*. *P. coronarius* (native to temperate eastern Asia) has been found as adventive species in Belgium since 1949, and may be naturalized, whereas *D. scabra* (native to China and Japan) is mentioned as a casual alien since 1984 (Verloove 2006). Both species have been found in several wooded sectors in the Domain, *P. coronarius* in 12 sectors and *D. scabra* in 9 sectors. Most of these sectors are situated in the central part of the Domain, which used to be part of the former castle estate of Meise (sectors 14, 16, 17, 32, 35 and 36); more remote locations where they have been found are in sectors 43 and 54. Moreover both species are present in the living collections.

Two different types of *Deutzia scabra*, both with double flowers, are present, sometimes growing close to each other. The first type has completely white flowers and is presumed to belong to cv. 'Candidissima', a variety created in 1865; the second type is presumed to be cv. 'Plena', an old Japanese variety that has been introduced in England in 1861. The flowers of the latter type are nearly double the size of the former type, and they have a pink stripe on the outer petal surface (de Koning *et al.* 2009).

Ribes alpinum, a small shrub from South, West and Central Europe, looks like the closely related *R. uva-crispa* but has lighter grey, thornless twigs. It is probably indigenous to the southernmost part of Belgium (Lorraine), but not to Flanders. Here it occurs very rarely in old park estates, where it has been planted, and in seminatural forests. It is mainly naturalized in and around Brussels (F. Verloove, *in* Van Landuyt *et al.* 2006), and non-indigenous populations also exist in several parks in Wallonia (Duvigneaud 1990). In the Royal Domain (Laken), some 6 km away from the Botanic Garden, it has been recorded as a stinsen plant (Saintenoy-Simon & Duvigneaud 2002). Within the Botanic Garden this shrub has been found in undergrowth in nine sectors with more or less natural vegetation; old accessions of it are (without date of origin) present in two sectors, and more recent accessions are grown in two more collection sectors.

Another exotic shrub that has frequently been planted in European gardens, where the English landscape style has been applied, is *Symphoricarpos albus*. Native to North America, it has been introduced as an ornamental shrub in England in 1817 (Bakker & Boeve 1985). It readily forms root suckers that allow the species to expand rather swiftly. In Belgium it has become naturalized during the 19th century, so that now it is rather common in Flanders, especially on loamy soils (F. Verloove, *in* Van Landuyt *et al.* 2006). The plants usually belong to var. *laevigatus* (Lambinon *et al.* 2004). *Symphoricarpos albus* grows in 28 sectors within the Domain, this is nearly 70 % of the wooded sectors. It also grows in botanical collections of the Garden, as well as other *Symphoricarpos* species, such as *S. occidentalis*, *S. orbiculatus* and several hybrids.

Other woody species

For some shrubs found as adventives it is not clear whether they have been planted in the Domain before the arrival of the Botanic Garden. *Aucuba japonica* has been considered a garden escape that was planted after 1938, while *Ligustrum vulgare* germinates outside the collections and is probably a garden escape too, but some specimens could be native. Some other shrubs and trees of exotic origin are probably present from before the arrival of the Botanic Garden, though their precise date of introduction is not known. One of these is *Aesculus hippocastanum*, a tree native to the Balkans which is frequently planted as an avenue tree and in parks; it sows itself and occurs naturalized in Belgium since 1980 (Verloove 2006). In Flanders spontaneous seedlings are rather common, although it is not yet clear whether they will reach adulthood and form naturalized populations (F. Verloove, *in* Van Landuyt *et al.* 2006). Seedlings have been found in the Domain in 32 sectors, this is three quarter of all sectors containing wooded parts. This tree could also be considered as an external neophyte, but it is more probable that the seedlings in the Botanic Garden have originated from an internal source.

Taxus baccata is probably no longer truly indigenous to Flanders; seedlings originating from cultivated plants are, however, frequently found (P. Van den Bremt, *in* Van Landuyt *et al.* 2006). Seedlings of this shade preferring shrub have been found in 37 sectors in the Domain.

Alnus incana, indigenous to North, Central and East Europe, has been planted in Belgium since the end of the 19th century. In the Botanic Garden it has been found in three sectors with rather natural vegetation.

Populus canescens, the presumed hybrid of *P. alba* and *P. tremula*, naturally occurs in a range stretching from Central and South Europe to western Siberia and the Himalayas. It is probably not native to Belgium, but is often recorded as an adventive species while it easily forms root suckers. It is often mistaken for *P. alba*, so that the distribution of these taxa in Flanders is not well known. It is obvious though that *P. canescens* occurs more to the east, on less sandy soils (P. Van den Bremt, *in* Van Landuyt *et al.* 2006). Both species have been planted in castle domains since the 18th century for timber production (de Pouderlee 1772). Especially *P. canescens* was frequently used as production tree of the first order because of its rapid growth, combined with the rather high quality of its wood (Tack *et al.* 1993). Later, however, it has been supplanted

by the arrival of the Canadian poplars. Within the Botanic Garden *P. canescens* is naturalized in 17 sectors, often only present with root suckers that have probably sprouted and survived long after the original trees had been cut.

Non woody species

Galanthus nivalis is a well-known stinsen plant that is present in numerous locations in the Botanic Garden; it has been recorded from 26 sectors. Vidts (2011) discusses their occurrence in the Domain and distinguishes two forms, one of which could be indigenous.

Arum italicum (Araceae) is a summer-dormant perennial. It has three subspecies, of which subsp. *italicum* has the most extensive distribution: North Africa, most of Europe south of the Netherlands, eastern and northern Turkey (Rice 2010). Formerly a subspecies *neglectum* was distinguished on the basis of leaf shape and leaf venation, but it is now included in subsp. *italicum* (Boyce 2006). In the Netherlands *A. italicum* is exclusively known as a stinsen plant; it was already found there in 1818, in the vicinity of Leiden. In England it has been cultivated since 1683 outside of its natural area in southern England, and has become naturalized there as a stinsen plant (Bakker & Boeve 1985). In Belgium, where it usually grows in castle parks and artificial habitats, it has been recorded from isolated localities. In Flanders it is rare and is considered to be mainly a stinsen plant (L. Vanhecke, *in* Van Landuyt *et al.* 2006), although it could be native in some locations (Vanhecke & Rammeloo 1978). Within the Domain it was first recorded in 1987 as mentioned by Duvigneaud (1990). *A. italicum* is currently present in twelve sectors, of which four are at the northern perimeter of the Domain; other sectors are close to the former homestead near the castle of Bouchout. In most sectors the plants have the typical silvery veined leaves of cultivar 'Marmoratum', but in sectors 19 and 29 plants lacking this venation pattern have been found.

At the edge of a moist deciduous forest (in sector 45) one non-flowering plant of *Pulmonaria saccharata* was found. Native to southeastern France and the Apennine mountains, it is cultivated as ornamental plant in gardens and parks. In Great Britain, where it has been cultivated since 1817, it has been found once naturalized in a forest (Anonymous 1930). In Belgium too it has been found as adventive, though less frequently than the related *P. officinalis* (Verloove 2006), which is known as a stinsen plant. According to Lawalrée (1949) *P. saccharata* has been in cultivation in Belgium since the 16th century and it has been found naturalized once in 1824 near Spa. It has also been found in 1975 in a forest near Waterloo (herb. J. Duvigneaud 75B233, in BR). *P. saccharata* is not cultivated in the collections of the Botanic Garden, and it is therefore suggested that it might have been planted as ornamental in the Domain before the transfer of the Botanic Garden to Meise. It is also possible, however, that it has escaped from a nearby garden.

Pentaglottis sempervirens is a perennial Boraginaceae that is native to Southwest Europe and Asia Minor. It is often planted in gardens and castle estates for its attractive blue flowers, and is now naturalized in Europe north of its original distribution area. It can behave as an invasive species, for instance in Great Britain, where it has strongly increased during the last forty years (Preston *et al.* 2002). Having been planted in the 18th century, it is today a persistent and increasing weed of the Royal Botanic Gardens, Kew, and its environs (Cope 2009). It mainly spreads by seed. In Belgium *P. sempervirens* has been recorded as an alien since 1836, and nowadays it is naturalized in all regions. It is, however, still very rare in Flanders, where it occurs as a stinsen plant in some localities (F. Verloove, *in* Van Landuyt *et al.* 2006). There is a large population in the Royal Domain in Laken, only 6 km away from Meise, from where plants have dispersed into neighbouring streets (Saintenoy-Simon & Duvigneaud 2002). In the Botanic Garden it grows in the (semi-) natural vegetation of sectors 38 and 45, where it has been recorded since 2002. As it is not present in the living collections, it is suspected to be a stinsen plant. More recently, it has also been found outside the Domain, in a forest edge at the perimeter of the castle domain of Bever-

hof (IFBL E4.15.12), some 3 km away, and at a roadside in Meise (D4.55.14), where it grows together with *Urtica dioica* and shows a tendency to expand despite yearly mowing of the vegetation.

Tellima grandiflora (Saxifragaceae), a perennial wood dweller from western North America, is frequently planted in castle domains, where it naturalizes. It has been introduced as an ornamental in Great Britain since 1826; it was first recorded from the wild in 1908 and is still spreading today (Preston *et al.* 2002). In Belgium naturalized populations have been found since 1932 (Verloove 2006). In Belgium and the Netherlands it has recently also been recorded from walls in urban areas (Denters 2004; http://users.skynet.be/fon/Artikels/Tellima_grandiflora.htm). In the Botanic Garden *T. grandiflora* has been found in undergrowth in seven sectors; it is furthermore present in botanical collections close to the orangery garden and in the herbetum. Taking into account the spatial distribution of the localities, it seems plausible that most plants in the Domain are stinsen plants rather than garden escapes. Some plants may, however, have reached the Domain from an external source and should then be considered as external neophytes. *T. grandiflora* also grows in the park of the nearby Beverhof domain in Strombeek-Bever; without genetic analysis it is not possible to tell whether a historical link exists between these populations and those in Meise.

The indigenous *Polygonatum multiflorum* grows at numerous locations in the Botanic Garden. In the sectors 20 and 28, however, the hybrid *Polygonatum ×hybridum* (*P. multiflorum* × *odoratum*) has been observed. It grows more vigorously than its parents and is known as stinsen plant in the Netherlands, where it has been cultivated since 1600 (Bakker & Boeve 1985). The plants in the Domain might also be stinsen plants, or they could have arisen by spontaneous hybridisation, as both parent species are present. A third possibility is that they are garden escapes, since the cultivar 'Weihenstephan' is cultivated in the fruticetum. Both locations are, however, rather far away from the fruticetum.

Viola odorata is often mentioned as stinsen plant: in the 16th century Dodonaeus reported that it was often taken from wild locations for cultivation in the garden. That is why the natural distribution area of the species is uncertain: it is thought to originate from around the Mediterranean and Atlantic Europe, perhaps including the loamy region of Belgium (P. Van den Bremt, *in* Van Landuyt *et al.* 2006). It has been found in lawns and forest edges in four sectors scattered over the Domain. A form with pinkish flowers has been found in sector 26 by P. Borremans.

Species introduced after 1938

The fern *Asplenium scolopendrium* has its main distribution area in West, South and Central Europe. It is rather rare in Flanders, where it mainly grows in artificial conditions (e.g. on walls) instead of calcareous rocks and ravine forest as it does in the wild (W. Van Landuyt & R. Viane, *in* Van Landuyt *et al.* 2006). In the Royal Domain in Laken, near Meise, it grows on the rocks of an artificial waterfall, where it has probably been planted, although it also occurs spontaneously in the Brussels region (Saintenoy-Simon & Duvigneaud 2002). In the Botanic Garden *A. scolopendrium* has been found in four locations, including two possibly 'natural' localities on a river bank, and one in the central courtyard of the herbarium building. The fourth locality is at the top of the so-called English gate, which was made by piling up rocks, and where tens of plants grow. The origin of this population lies in the former Botanic Garden in Brussels: plants brought from Brussels were cultivated in the old nursery in sector 71, before being moved to the English gate (pers. comm. P. Borremans).

Hyacinthoides non-scripta is an Atlantic ancient forest plant with a restricted natural distribution range in western Europe, including a small part of Flanders (P. Van den Bremt, *in* Van Landuyt *et al.* 2006). Meise is situated at the northern border of its natural range, but apparently it was not present in the Domain before 1938. In 1967 plants from a botanic garden in France were planted in several sectors,

mainly in collections but also in some (semi-) natural vegetation. Moreover, in 1978 plants from wild populations in a forest near Kwaremont (prov. Oost-Vlaanderen) were planted in the vicinity of The Machoechel (sector 56) by E. Lammens, the former curator of the living collections of the Botanic Garden. From 2008 on, *Hyacinthoides* seedlings have been found in other locations in the Domain, but most of these are probably of hybrid origin (*Hyacinthoides ×massartiana*, the hybrid between *H. hispanica* an *H. non-scripta*); see the contribution on external neophytes in this volume (Ronse 2011a).

Lathraea clandestina has a natural distribution range that is mainly restricted to parts of France and Spain, with an additional small disjunct part in Belgium. It's a root parasite on several tree species, usually found in alluvial areas (P. Van den Bremt, *in* Van Landuyt *et al.* 2006). It was introduced to Meise from a forest in Ronse in 1979 by E. Lammens. Today it still grows and flourishes in natural woody vegetation by rivulets in the very same sectors 44 and 45 where it has been introduced, as well as in sector 31, where it was also recorded by Van Mello (2001). The same species has also been introduced on trees at the Royal Botanic Gardens, Kew, where it is not native but seems to be spreading (Cope 2009).

Rhinanthus minor, a hemi-parasite that parasitizes grasses and numerous other species, is native to Europe and further eastward into Central Asia. It prefers nutrient-poor to rather eutrophic conditions, and is rather rare in Flanders. In the Domain it has been introduced in 1979 in sector 57, near De Machoechel, and in sector 44, now called 'Wild Meise'. The seeds had been harvested in a meadow in Canly (Oise, France), and both populations are still present after more than thirty years.

Narcissus pseudonarcissus subsp. *pseudonarcissus* is native to Belgium. In Flanders it occurs principally in forests in the loamy region. Plants from the Hautes Fagnes (in the eastern part of Belgium) have been introduced in sectors 57, 58 and 59 in 1978 and 1979. They are still present and flower each year in sector 59. Other *Narcissus* have also been planted in the Domain in less natural locations, and some of these have escaped. In 2001 Van Mello recorded wild daffodils in sectors 36 and 44; they had probably escaped from the *Narcissus* hybrids 'Butter and Eggs' which have been growing in a lawn in the higher but adjacent sector 39. Recently, no *Narcissus* have been observed in these sectors. The cultivated *N. cyclamineus* hybrid 'Jenny' has also been planted in the lawn at the foot of the 'Tempel of Friendship' (sector 26) in 2000.

Several terrestrial orchid species have been introduced into the Domain outside the collections after 1938, mainly *Dactylorhiza* species. Most of these plants were indigenous orchids from several different locations in Belgium. *D. praetermissa* and *D. maculata* from southern Belgium were planted in sector 44 (now part of 'Wild Meise') by E. Lammens. In 1980 L. Vanhecke planted some two hundred specimens of *D. praetermissa* in sector 44 (now part of 'Wild Meise'); these plants originated from Lissewege (prov. West-Vlaanderen) where a new container terminal for the sea harbour of Zeebrugge was being built. Individual specimens were planted according to a grid system and at mutual distances of 3 m from one another. Their survival was followed year after year during more than ten years. Some of these orchids were measured for morphometric research and their vegetative propagation was recorded (Vanhecke 1989).

Between 1975 and 1981 plants of *Dactylorhiza maculata*, *D. praetermissa*, *D. fuchsii* and *D. majalis* of Belgian and French origin were introduced by E. Lammens in sector 57, close to the Machoechel. Several different *Dactylorhiza* had already been recorded from this part of the Domain in the 1940s, after the Botanic Garden had been transferred from Brussels; they had however disappeared due to ground works to prepare the laying out of the collections in Meise. Most of the newly introduced *Dactylorhiza* survived and thrived in the humid grassland that was managed as a meadow. In the beginning, the vegetation around the orchids was cut manually, in order to create better light conditions. Soon the different species began to propagate and hybridize, so that

plants with intermediate characteristics are now present. Many orchids are still present in this area that today is managed as natural grassland.

In the same period E. Lammens also introduced some other orchid species in sector 57 (the Machoechel) that, as far as is known, had not been recorded before from the Domain. One example is *Anacamptis pyramidalis*, introduced from France and still present in the early nineties; it seems, however, to have disappeared soon after. *Ophrys insectifera*, introduced from Lorraine (France) survived for a few years only.

During the last decade several *Dactylorhiza* have spread to other parts of the Domain, especially after 2006 due to a changing grassland management regime. Many lawns, for instance, are now less frequently mown than before. This has created opportunities for seed dispersal into new sectors by several different orchid species. As a result, some are now present in at least ten sectors, and they seem to be in full expansion. Some grassland had already been mown less frequently earlier, for example in sector 45 which has been managed as meadow since 2002. Since that year a large *Dactylorhiza* population has developed there spontaneously, probably with seedlings originating from the *D. praetermissa* plants that had been introduced in the neighbouring sector 44. In the latter sector, however, most orchids have disappeared due to the development of tall vegetation with sedges. On the whole, the most frequently observed species in the Domain in recent years has been *Dactylorhiza maculata*, a rather rare species in Flanders. It has been found in nine sectors, usually accompanied by *D. praetermissa* and/or *D. fuchsii*, and plants with intermediate characteristics. *D. praetermissa* was reported in seven sectors close to the castle of Bouchout and the Machoechel, and in Wild Meise, and *D. fuchsii* in four sectors. All of these orchids thrive in humid to moist grasslands that are not mown before approximately 15 July.

Conclusion

In the Botanic Garden several plants have been deliberately introduced outside the collections either before or after the transfer of the Botanic Garden from Brussels to Meise in 1938. In total 25 species have been found that are naturalized or have dispersed spontaneously, mostly in (semi-) natural areas. These plants include trees and shrubs as well as herbaceous species, and some of them are bulbs. They can be found mostly in the wooded areas, and sometimes in grasslands. Of all wild and naturalized plants observed in the Domain, 3% are (descendants of) deliberate introductions outside the collections. This is a low percentage when compared to the percentages (20 to 33 %) found by Nath (1990) in some historical estates in Germany. This is at least in part explained by the fact that the Botanic Garden has a high number of species escaped from the botanical collections, while such species are not present in the other estates.

The five most frequently encountered species (in more than 25 sectors) are *Taxus baccata*, *Aesculus hippocastanum*, *Acer platanoides*, *Symphoricarpus albus* and *Galanthus nivalis* (in decreasing order). These species are also frequently present in forests in the loamy region in the neighbourhood of the Domain; they have been introduced before the Domain was selected as a new site for the National Botanic Garden of Belgium. Other species also present in more than five sectors are *Populus canescens*, *Philadelphus coronarius*, *Arum italicum*, *Deutzia scabra*, *Ribes alpinum*, *Tellima grandiflora*, *Hyacinthoides non-scripta*, *Dactylorhiza maculata* and *D. praetermissa*.

Eight species can be described as stinsen plants, in other words: they belong to a group of species that were frequently introduced in castle estates and parks in the 19th century or earlier, mainly because of their ornamental value. Some other stinsen plants have also been found in the Domain, but they have been considered here to be garden escapes, because of their location close to cultivated specimens in the living collections. Examples are *Inula helenium*, *Lamium maculatum* and *Doronicum pardalianches*, which are treated in another contribution in this volume (Ronse 2011b). Nine species are known to have been (re)introduced after 1938 in the Botanic Garden; these are of-

ten species of botanical interest or with a high conservation value, such as *Lathraea clandestina*, *Rhinanthus minor* and several orchids of genus *Dactylorhiza*.

The origin and the dates of introduction are often not known, except for the more recent introductions after 1938. For several species it is not even certain they have been intentionally introduced: they might also have arrived as escapes from neighbouring gardens, even if the dispersal of many species is probably somewhat hampered by the woody belt at the perimeter of the Domain. Another possibility is that certain species actually are collection escapes from the living collections within the Botanic Garden. Indeed, some species can disappear from the collections after several years of cultivation, but still be present in the Domain outside the collections. An example is *Mentha pulegium*, a garden escape that thrives in several lawns (Ronse, in prep.). For species that were cultivated before 1988 no digital records exist, and an investigation to find out if a species has been cultivated before that date would involve a long and time-consuming search in old record books.

Nearly half of all deliberately introduced species are (very to rather) rare. Half of the pre-1938 introductions are common or rather common in Flanders, while three species are very rare or rare (*Pentaglottis sempervirens*, *Ribes alpinum* and *Arum italicum*). For the remaining five species (= 30 %) no information on their frequency is available, as they are not mentioned in the Flemish plant atlas (Van Landuyt *et al.* 2006). Of these, *Tellima grandiflora* is mentioned as 'naturalized' in the catalogue of neophytes in Belgium (Verloove 2006), *Philadelphus coronarius* as 'naturalized?', *Deutzia scabra* as 'casual', and *Pulmonaria saccharata* as 'casual?'; *Polygonatum ×hybridum* is not mentioned at all.

The more recently introduced species (after 1938) are all but one rare in Flanders. On the whole, this group of plants is of some interest for conservation purposes, though this is restricted because the plants have usually not originated from autochthonous material.

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Literature

Anonymous (1930) – New county and other records, 1930. *Rep. Bot. Soc. Exchange Club British Isles* **9 (3)**: 331-379.

Bakker P. & Boeve E. (1985) – Stinzenplanten. Zutphen & 's-Graveland, Terra & Vereniging tot Behoud van Natuurmonumenten in Nederland.

Boyce P. (2006) – New observations on Arum italicum. *The Plantsman n.s.* **5 (1)**: 36-39.

Cope T. (2009) – The Wild Flora of Kew Gardens. A cumulative checklist from 1759. Kew, Kew Publishing.

de Koning J., van den Broek W., De Meyere D. & Bruens H. (2009) – Dendrologie van de Lage Landen. Zeist, KNNV Uitgeverij.

Denters T. (2004) – Stadsplanten: veldgids voor de stad. 's-Graveland, Fontaine Uitgevers.

de Pouderlee (1772) – Manuel de l'Arboriste et du Forestier Belgiques. Bruxelles, J.L. de Boubers.

Duvigneaud J. (1990) – Quelques observations floristiques effectuées à proximité du chateau de Houx (Yvoir, province de Namur, Belgique). *Natura Mosana* **43 (1)**: 10-14.

Lambinon J., Delvosalle L. & Duvigneaud J. (2004) – Nouvelle Flore de la Belgique, du Grand-Duché de Luxembourg, du Nord de la France et des Régions voisines. 5e Edition. Meise, Jardin botanique national de Belgique.

Lawalrée A. (1949) – Les Pulmonaria de Belgique. *Bull. Soc. Roy. Bot. Belg.* **82 (1)**: 97-102.

Nath M. (1990) – Historische Pflanzenverwendung in Landschaftsgärten. Worms, Wernersche Verlagsgesellschaft.

Preston C.D., Pearman D.A. & Dines T.D. (2002) – New atlas of the British & Irish flora. Oxford, Oxford Univ. Press.

Rice G. (2010) – Arum italicum and its cultivars. *The Plantsman n.s.* **9 (4)**: 212-217.

Ronse A. (2011a) – External neophytes. *Scripta Bot. Belg.* **47**: 77-88.

Ronse A. (2011b) – 'Botanical garden escapes' from the living collections at the Botanic Garden. *Scripta Bot. Belg.* **47**: 89-111.

Ronse A. & Vidts S. (2011) – A short history of the land use and vegetation of the Botanic Garden. *Scripta Bot. Belg.* **47**: 19-26.

Saintenoy-Simon J. & Duvigneaud J. (2002) – Le domaine royal de Laeken. *Adiata* **34**: 27-31.

Tack G., Van den Bremt P. & Hermy M. (1993) – Bossen van Vlaanderen: een historische ecologie. Leuven, Davidsfonds.

Vanhecke L. (1989) – Intraclonal variation and intercorrelation of morphological characters in Dactylorhiza praeter-

missa: evidence for allometry in Orchidaceae. *Mém. Soc. Roy. Bot. Belg.* **11**: 65-86.

Vanhecke L. & Rammeloo J. (1978) – Arum italicum in de Polders. *Dumortiera* **10**: 31.

Van Landuyt W., Hoste I., Vanhecke L., Van den Bremt P., Vercruysse W. & De Beer D. (2006) – Atlas van de flora van Vlaanderen en het Brussels Gewest. Brussel & Meise, INBO, Nationale Plantentuin van België & Flo.Wer.

Van Mello W. (2001) – Inventarisatie van enkele kenmerkende soorten van de voorjaarsvegetatie in het Domein van Bouchout. Meise, Nationale Plantentuin van België.

Verloove F. (2006) – Catalogue of neophytes in Belgium (1800-2005). *Scripta Botanica Belgica* **39**. Meise, National Botanic Garden of Belgium.

Vidts S. (2011) – Galanthus nivalis in de Nationale Plantentuin: een mix van archeofyten en stinsenplanten. *Scripta Bot. Belg.* **47**: 131-138.

Scripta Botanica Belgica **47**: 77-88 (2011)

External neophytes

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Scripta Bot. Belg. **47**: I. Hoste (ed.), The spontaneous flora of the National Botanic Garden of Belgium (Domein van Bouchout, Meise)

Résumé. – Les néophytes externes du Jardin botanique. Dans le Domaine 42 espèces de néophytes ont été inventoriées, qui se sont probablement propagées à partir de populations en dehors du Domaine. Chaque espèce est traitée dans le texte, reprenant l'aire de distribution originale et secondaire, le caractère invasif si tel est le cas, l'historique de l'espèce en Belgique, et sa survenance dans le Domaine. La fréquence des espèces dans le Domaine et à l'extérieur dans la région limoneuse et en Flandres sont comparées, montrant que certaines espèces sont surreprésentées dans le Domaine, tandis que d'autres sont sous-représentées. Parmi les néophytes de provenance extérieure 14 espèces se trouvent sur la liste des espèces invasives en Belgique.

Samenvatting. – De externe neofyten van de Nationale Plantentuin. In het Domein werden 42 soorten neofyten van vermoedelijk externe bron aangetroffen. Elke soort wordt kort besproken, waarbij het oorspronkelijk en het secundair verspreidingsgebied aan bod komen, haar al dan niet invasief karakter, de historiek van de soort in België, en het voorkomen in het Domein. De frequenties van de soorten in het Domein en daarbuiten in de leemstreek en in Vlaanderen worden vergeleken, waaruit bepaalde soorten naar voren komen die relatief vaker in het Domein aanwezig zijn, en andere die ondervertegenwoordigd zijn. Van de externe neofyten staan 14 soorten op de lijst van invasieve soorten in België.

Introduction

In total 42 vascular plant species in the Domain of the National Botanic Garden of Belgium have been identified as 'external neophytes': they have also been recorded from the area surrounding the Domain and it is supposed that the populations within the Domain originate in these neighbouring populations, and not in the living collections of the Botanic Garden. In not having originated from the collections they differ from 'collection escapes', a separate category of neophytes (see Ronse 2011). The external neophytes are listed in table 1 in alphabetical order, together with the number of sectors of the Domain where they have been observed.

In order to check which species can be considered neophytes, the *Catalogue of neophytes in Belgium* (Verloove 2006a), the plant atlas of Flanders (Van Landuyt *et al.* 2006) and the fifth edition of the *Nouvelle Flore de la Belgique* (Lambinon *et al.* 2004) have been consulted. However, for some species the interpretation differs according to the source. *Echinochloa crus-galli* for example has been considered a neophyte, an archaeophyte or even an indigenous species. The list in this contribution should therefore be viewed as provisional.

Species of the genus *Cotoneaster* are missing in the table and in the discussion of the species. Young plants of ten different species have been found in the Domain, but most have not been identified with certainty. It is indeed very difficult to identify them in the absence of flowers and/or fruits. Moreover, of the observed ten species, eight were tentatively classified as collection escapes. In the Botanic Garden about fifty different species and additionally about

Table 1. External neophytes and the number of sectors where they have been observed

Species	# sectors
Amaranthus blitum	7
Buddleja davidii	8
Chamaesyce humifusa	3
Claytonia perfoliata	1
Conyza canadensis	18
Conyza sumatrensis	5
Coronopus didymus	9
Cymbalaria muralis	1
Cyperus eragrostis	1
Duchesnea indica	31
Echinochloa crus-galli	5
Epilobium ciliatum	10
Fallopia x bohemica	2
Fallopia japonica	8
Galinsoga parviflora	6
Galinsoga quadriradiata	9
Geranium pyrenaicum	1
Heracleum mantegazzianum	3
Hieracium aurantiacum	1
Hyacinthoides x massartiana	3
Impatiens glandulifera	4
Impatiens parviflora	33
Lemna minuta	1
Matricaria discoidea	5
Myosotis alpestris	1
Oenothera deflexa	2
Oxalis corniculata	3
Oxalis fontana	5
Phytolacca acinosa s.l.	10
Portulaca oleracea	11
Potentilla norvegica	1
Prunus laurocerasus	30
Prunus serotina	15
Robinia pseudoacacia	5
Rosa multiflora	1
Sanvitalia speciosa	1
Sedum rupestre	1
Senecio inaequidens	12
Solidago canadensis	2
Veronica filiformis	36
Veronica peregrina	23
Veronica persica	18

fifteen varieties are cultivated. However, in the plant atlas of Flanders only five species of *Cotoneaster*, all common or increasing, have been treated (Van Landuyt *et al.* 2006). In some cases the plants in the Domain were observed not far from the cultivated plants, and some have typical leaf morphology, making them easier to identify. Two species have been more confidently named and considered to be external neophytes, namely *C. salicifolius* and *C. horizontalis*. The latter was the first *Cotoneaster* species known to naturalize and spread in Belgium; the naturalization of *C. salicifolius* is more recent.

Discussion of the species

In the following text each neophyte species is treated separately. The brief treatment deals with the original distribution range and data from Belgium, as well as the distribution in the Botanic Garden. The two main sources for the distribution data are the plant atlas of Flanders (Van Landuyt *et al.* 2006) and of the Brussels Region (Allemeersch 2006).

• *Amaranthus blitum*, from the Mediterranean, has probably been present in Flanders for some centuries. Recently it has strongly increased, maybe due to global warming (Verloove *in* Van Landuyt *et al.* 2006). In the Domain it has been found in seven sectors, always in plant beds where the soil has been repeatedly disturbed; it appears to have increased during the last few years. *Amaranthus blitum* has also been observed in the Royal Domain in Laken, less than ten kilometres away. In the region of Brussels it is a common species (Allemeersch 2006; Saintenoy-Simon & Duvigneaud 2002).

• *Buddleja davidii*, from China, has been planted in Europe as an ornamental shrub since the end of the 19th century. It has naturalized swiftly since the first report as an alien in Belgium in 1942. After 1970 it has become a very common exotic species in urban areas. It is mentioned on the watch list of invasive species in Belgium (Branquart 2011) as a widespread plant with moderate adverse impact on native species and ecosystems. In the Domain it has been observed in eight sectors.

• *Chamaesyce humifusa* (syn.: *Euphorbia humifusa*) is a small annual spurge from Southeast Asia that has naturalized in several parts of Europe and Southwest Asia (Benedi & Orell 1992). It has been recorded from several botanic gardens, such as Dahlem (Berlin), where it has been introduced from the ancient garden

at Schöneberg where *C. humifusa* had already been reported in 1814. Now it occurs on gravel paths and in borders in the Dahlem garden (Sukopp 2006). A similar story is known for the Botanic Garden in Meise, as the species has come from the former location of the Botanic Garden in Brussels. A herbarium specimen from the systematic garden in Rue Royale in 1900 testifies that this prostrate spurge grew there in this part of the garden. In Meise hundreds of plants were known to grow as weeds in the walled orangery garden at least since 1980 (Jongepier & Robbrecht 1986a, 1986b). It is likely that it has survived in the former Botanic Garden location in Brussels for decades, and that it has been brought in when plants were moved from Brussels to Meise. Nowadays the species is still present there on the paths, and plants are present in the neighbouring nurseries of sector 23, where they reseed each year. It is also present in the new systematic garden (the herbetum), where it is grown in several different plant beds and is rather common; in the same sector some plants also grow in the Balat greenhouse, an unheated greenhouse.

• *Claytonia perfoliata*, an annual from North America, is rather common in Flanders. It is strongly advancing from the West, where it had its strongholds in the dunes. In the Domain it has, rather surprisingly, been found only under a tree in the fruticetum.

• *Conyza canadensis*, from North America, has become cosmopolitan. Before long it had invaded large parts of Europe. Today, this pioneer species of dry places is widespread and extremely common, but still increasing. In the Domain it has been seen on disturbed places in nearly twenty sectors.

• *Conyza sumatrensis*, from South America, has been an adventive species in South Europe for some time. The first record in Flanders dates from 1990. During the nineties it increased quickly, especially in urban areas. A similar recent expansion is also taking place in the Botanic Garden, where one specimen was found in 2007 close to the soil repository. In 2008 *C. sumatrensis* was found in two other sectors in remote areas, in 2009 in yet another sector, and in 2010 in a fifth sector. Each location contained only one plant, but we expect that the species will quickly expand in the near future. It needs disturbed spots to settle, just like *C. canadensis*.

• *Coronopus didymus*, from South America, is a low growing pioneer on open, moist eutrophic soils. It has colonised large areas worldwide, and has shown a spectacular expansion in Flanders, where it is now common. In the Domain it has been observed in nine sectors, and the number is increasing.

• *Cymbalaria muralis* has its natural distribution range in the Mediterranean, more precisely in the Alps near the Adriatic Sea. It is widely naturalized elsewhere, including in Flanders, since the second half of the 16th century. It is rather common and grows mainly on stony substrates such as walls. In the Domain it has been recorded from the pavements around the greenhouses of the Plant Palace.

• *Cyperus eragrostis*, native to the western United States, has become naturalized across North America, Europe, and parts of South America and Australia. It sometimes behaves as a weed, e.g. in rice fields. It has rapidly spread in recent decades in southern and western Europe, and also in Belgium, where it was first observed in 1896. In Belgium it remained uncommon until the 1990s, when a rapid expansion set in, especially in Flanders. The plant colonises (rather) eutrophic sites with standing water during winter (Verloove 2006b). It is listed on the watch list of invasive species in Belgium, due to its high reproductive capacity and a high dispersal potential. There are concerns that it might out-compete and displace other native plant species (Branquart 2011). In the Domain a few plants of it were found in 2009 in a rather natural vegetation of tall grasses and sedges of sector 45.

• *Duchesnea indica*, native to Asia, is very similar to strawberry but has yellow flowers and unpalatable fruits. In Europe it was introduced as an ornamental, mainly in castle parks. That was also the case in Belgium, where it was first recorded as an alien from a park in

Brussels. There is an obvious concentration of localities near Brussels, and the rapid progress of the species between 1991 and 1993 in different parks in that area has been described by Saintenoy-Simon *et al.* (1995). Recently it has spread all over the country, and it is listed on the watch list of invasive species in Belgium (Branquart 2011). It can spread and multiply by seeds, which are eaten and disseminated by birds, and by stolons forming dense mats. In the Botanic Garden *D. indica* has been found in 31 sectors, and a steady year by year increase of the number of localities has been observed during the ten year period of our floristic mapping. This species is found mainly in wooded, shaded areas, but also in the borders of lawns and under solitary trees. Since it has also been kept in the collections since 1976, it may also occur as a collection escape. However, it is considered an external neophyte because of its rapid expansion in the whole region in and around the Domain.

• *Echinochloa crus-galli* is mentioned in the catalogue of neophytes in Belgium (Verloove 2006a), but is considered elsewhere as introduced in Belgium since prehistoric times (Hoste *in* Van Landuyt *et al.* 2006). It is extremely common in Flanders, showing a preference for disturbed soils. In the Domain it has been recorded from nurseries and flower beds in five sectors.

• *Epilobium ciliatum*, native to North America, has been introduced to Europe, where it mainly thrives in man-made environments: arable land, gardens, tree nurseries, clear-cut and ruderal areas. It is one of the arable weed species with the highest rate of increase in Europe, and is mentioned on the list of invasive species in Belgium (Branquart 2011). In the Domain it has been found in ten sectors.

• *Fallopia japonica*, originally from Asia, is widely known to be one of the most invasive plant species in Europe (Beerling *et al.* 1994). It has the highest ranking on the black list of invasive species in Belgium, being a widespread species with a high environmental impact. *Fallopia japonica* is able to form dense, mono-specific and persistent populations. Its expansion locally reduces plant and invertebrate species diversity, alters habitat for fish and wildlife, changes light and energy conditions of the ecosystem, and promotes riverbank erosion during the winter (Branquart 2011). In the Botanic Garden it grows in eight sectors. It grows in nurseries and collections, but has also been found in more natural vegetation (sectors 43 and 44), where it should be closely monitored. It has been cultivated in the herbetum, but was eliminated in 2008 because of its aggressive behaviour. In 2011 these eradication efforts have still not succeeded completely, despite removing the soil from the planting area up to a depth of 1 m and despite the use of herbicides. A few remaining rhizome parts still regenerate into plants.

• *Fallopia ×bohemica*, the hybrid between *Fallopia japonica* and *F. sachalinensis* (which is much rarer), shows hybrid vigour and is reputed to be more invasive than its parents. It typically forms very dense stands, excluding native vegetation and preventing regeneration. It is listed on the black list of invasive species in Belgium as a species with high environmental hazard and a restricted range (Branquart 2011). It has been reported as a rather frequent neophyte in the region of Brussels by Meerts & Tiébré (2007) who also found one location close to the Botanic Garden, in Strombeek-Bever (IFBL E4.15.21). In the Domain itself it was recorded from one location in sector 53, in spontaneous tall vegetation on wet soils in a forest edge, together with a.o. *Cirsium oleraceum*, *Heracleum sphondylium*, *Mentha ×piperita* and *Humulus lupulus*.

• *Galinsoga parviflora*, a pioneer species native to South America, has been mentioned in Belgium since the first half of the nineteenth century. Today it is common in Flanders, especially in regions with sandy soils, where it mainly occurs as weed in arable land, in gardens and along roadsides. In the Domain it has been found in six sectors, usually in disturbed sites.

• *Galinsoga quadriradiata*, native to South America, has not been recorded from Belgium

before the twentieth century. It is a pioneer species that occurs in similar locations as *G. parviflora*, but it displays a broader ecological amplitude. It also thrives on more loamy soils, and that is why it is more widespread in Flanders. It usually occurs in larger quantities than *G. parvivlora*, and this is also the case in the Botanic Garden, where it has been recorded from nine sectors.

• *Geranium pyrenaicum*, native to Central Europe and the eastern Mediterranean, is rather common as neophyte in Flanders, and has spectacularly increased during the last decade. This has also been the case in the northwestern part of the province of Vlaams-Brabant and in the vicinity of the Botanic Garden (Ronse 2005). It grows mainly in grassy roadsides, but also occurs in ruderal locations. In the Domain it grows near to the nursery in sector 23, where it is not cultivated. It is, however, kept in the collection in the herbetum, at the other side of the Domain.

• *Heracleum mantegazzianum* is listed on the black list of invasive species in Belgium as a widespread alien with high environmental impact. Its enormous height and leaf area enable it to overtop and out-compete most indigenous herbaceous plant species. Besides these ecological problems, it also represents a serious health hazard for humans, while the plant exudes a clear watery sap containing compounds that can cause severe burns to the skin (Branquart 2011). In Flanders it has first been observed in the wild in 1938, and since then it has increased enormously; it is now rather common. In the Domain plants have been found in sectors 51 (seedlings), 54 and 43. Especially the latter sector is a valuable area with natural vegetation, where it has probably arrived with the river. In the two other sectors it is considered as collection escape.

• *Hieracium aurantiacum*, native to the mountain regions of central and southern Europe, is often planted in gardens for its showy orange coloured flowers. It is naturalized in various parts of the world, and it is known as a noxious weed in North America and Australia. It has been observed in the wild in Belgium since 1910 (Verloove 2006a), and is now rare in Flanders, occurring mainly in lawns. It has been recorded from around the Domain, for instance from Meise (pers. obs. AR, IFBL D4.55.13). In the Domain it has been found in one sector only. Although the species is cultivated in the herbetum, it has been considered as external neophyte, because it was found at the other side of the Domain and occurs outside the Domain as well.

• *Hyacinthoides ×massartiana* is the hybrid between *H. non-scripta* (indigenous to forests in the loamy region) and *H. hispanica* (native to the Iberian Peninsula). The latter species is frequently planted in gardens as ornamental and has been reported as increasing in range and frequency in Great Britain (Preston *et al.* 2002). In Flanders too it is rapidly expanding. It hybridises freely with *H. non-scripta*, and the highly fertile hybrids are increasingly found as adventive plants. Both *H. hispanica* and *H. ×massartiana* can invade the native populations of *H. non-scripta*, and introgression occurs. It is not always easy to identify the plants that are increasingly found in Flanders (Verloove *in* Van Landuyt *et al.* 2006). In the Botanic Garden seedlings of *Hyacinthoides* have been recorded more frequently in several different sectors since 2008. They have been considered here as external neophytes, since plants of these taxa are present as neophytes in the Brussels region, but they might as well be garden escapes. Indeed, both parent species are cultivated in several locations in the Garden. However, they have been cultivated for more than forty years, and it is only recently that seedlings have been found, sometimes in remote locations.

• *Impatiens glandulifera*, an annual species native to the Himalayas, is naturalized in large parts of Europe. It competes with other plant species on eutrophic wet soils. Owing to its very high nectar production, it could threaten indigenous species through competition for pollinators (Chitka & Schurkens 2001). *I. glandulifera* may form dense stands that shade out and replace native annual and even peren-

nial plant species due to its early germination and rapid growth. It is mentioned on the black list of alien invasive species in Belgium as a widespread plant with high environmental impact (Branquart 2011). It mainly thrives along rivers and brooks, and its seeds quickly spread by means of running water. It is common in Belgium, and has been recorded from four sectors in the Botanic Garden, especially along the Maalbeek to the north of the Domain, but also within the herbetum, where it is cultivated.

• *Impatiens parviflora*, native to central Asia, is naturalized in large parts of Europe, where it escaped from botanic gardens in de 19th century, and in North America (Van der Meijden *et al.* 1989). It is the only exotic plant being dispersed on a large scale in European forests. Preferring shaded and moist nutrient-rich stands, it can also develop in acidic conditions. It thrives in beech and alder woodland, but also in parks, hedgerows, forest edges, waste ground and ruderal habitats. It has been put on the watch list of invasive species in Belgium as a widespread species with moderate environmental impact (Branquart 2011). It is strongly expanding in Flanders, and is frequently found in Vlaams-Brabant. In the Botanic Garden it has been found in 33 sectors, nearly all sectors with wooded areas.

• *Lemna minuta*, from North America, forms dense floating mats at the water surface, and so reduces light penetration and gas exchange. It has been observed in Belgium since 1983. In Flanders it is still considered rare, but it is easily confused with *L. minor*, which is native to Belgium. *L. minuta* has been placed in the watch list of invasive species in Belgium, as a widespread species with moderate environmental impact (Branquart 2011). In the Domain it has been found in one location, in tanks for aquatic plants.

• *Matricaria discoidea*, probably native to East Asia and northwestern North America, is widespread in the cold and temperate parts of both the northern and southern hemisphere. It is extremely common in Flanders, where it has experienced a very explosive expansion in the early decades of the 20th century. Within the Botanic Garden it has been found in five sectors, on disturbed ground.

• *Myosotis alpestris* is native to Europe, West Asia and North America. In Europe its natural range is restricted to Central and South Europe (Grau & Merxmüller 1972). This forget-me-not can be confused with *M. sylvatica* (Stace 2001). It is planted in gardens and shows a tendency to sow itself, but is not mentioned in the catalogue of neophytes in Belgium (Verloove 2006a). However, a single plant found in the Botanic Garden has been identified as *M. alpestris*.

• *Oenothera deflexa* (often wrongly called *O. parviflora*), native to North America, has been mentioned as invasive alien in Belgium. It is often recorded from disturbed and anthropogenic habitats (waste sites, stony areas, abandoned fields, railway embankments, etc.), yet it also colonises semi-natural habitats (dry grassland, quarries, sandpits and dunes), usually at low densities. It only establishes on vegetation-free spots and therefore its capacity to out-compete native plant species is rather limited (Branquart 2011). It is rather common in Flanders, and has been recorded from a few sectors in the Botanic Garden.

• *Oxalis corniculata*, from the Mediterranean, was already mentioned as being in 'Belgium' in the 16th century by Dodoens (1554). It has expanded strongly in the 20th century and is now rather common in Flanders as a pioneer in plantations, gardens and ruderal terrains. It is considered a troublesome weed because it rapidly sets seed and has thickened roots that are difficult to eradicate. In the Botanic Garden it has been found in three sectors; it often occurs as weed in the greenhouses.

• *Oxalis fontana*, rather similar to *O. corniculata*, is native to North America and has settled in Europe during the 17th century. Very common in Flanders, it thrives in similar circumstances as *O. corniculata*, but does not root on stem nodes like the latter. In the Domain it has been found in five sectors. Sometimes both species occur together, as in sectors 23 and 64.

• *Phytolacca acinosa* s.l. is a complex of closely related species that are difficult to distinguish. It includes *P. esculenta*, a species native to eastern Asia that is mentioned in the Flemish plant atlas. The other species in this complex are *P. acinosa* and *P. latbenia* (Clement 1998). *P. esculenta* has been planted for a long time as an ornamental in gardens. It grows to a height of two metres and has whitish or pink flowers and dark red to black berries. In Flanders it has been reported as extremely rare, but very rapidly increasing. It shows up in urban areas, and might well be on the verge of naturalization. Birds spread this plant over medium long distances by eating the fruits. In the Botanic Garden plants of *P. acinosa* s.l., which is also present in the living collections, have been found in nine sectors, scattered over the estate.

A related potentially invasive species is *Phytolacca americana*, that is naturalized in large parts of Europe, Australia and Asia from North America according to the Global Compendium of Weeds (http://www.hear.org/gcw/species/phytolacca_americana/), but that has not yet been found in Belgium according to Branquart (2011). There are, however, reports of invasive behaviour of the species in nature reserves in Flanders (De Beelde & Struyve 2008), but these findings might well concern *P. acinosa* s.l., as both species can easily be confused. In Great Britain the most frequently occurring *Phytolacca* appears to be *P. acinosa* s.l., the other species being much rarer (Clement 1998). In the Botanic Garden *P. americana* is present in the collections, but it has not been recorded outside the planting area.

• *Portulaca oleracea* is a pioneer species of fields and ruderal sites such as graveyards and railroad sides. Its original distribution range is not known, but it occurs worldwide in tropical regions and in temperate regions of the northern hemisphere. In Flanders it has been observed as a neophyte since the 19th century; all over the region the number of localities has quickly increased. A rapid expansion has also been described from northern France (Bedouet 2009). Within the Botanic Garden it has been found in eleven sectors, usually as a weed on hacked spots in nurseries and flower beds; it appears to be increasing.

• *Potentilla norvegica*, from North America, has been naturalized for some time in large parts of Europe. It only rarely occurs in Flanders, usually on rather dry and sunny sites. In the Domain it has been observed only once for a short time, growing close to a heap of soil in the vicinity of the greenhouse complex of the Plant Palace. It is not cultivated in the collections of the Botanic Garden.

• *Prunus laurocerasus*, from Asia, is often used in hedges or as an ornamental bush. It is mentioned on the watch list of invasive species in Belgium as a species with isolated populations and moderate impact. In recent years, seedlings are increasingly observed in the wild in Belgium. In South and Central Europe numerous invasion histories of this species are known, where the plant rapidly spreads by root suckering, layering and stump sprouting (Branquart 2011). In the UK as well, this species has experienced a rapid expansion (Preston *et al.* 2002). In the Domain it has been found in thirty sectors, in nearly all wooded parts of the Botanic Garden. Seedlings often grow in shaded areas. *P. laurocerasus* is also cultivated in four sectors, but since it is so often found in the northwestern part of Vlaams-Brabant (pers. obs. AR), it is assumed that many of the plants growing in the wild in the Domain are not escapes from the living collections.

• *Prunus serotina*, native to eastern North America, has been planted and is naturalized in many European countries. It is mentioned on the black list of alien invasive species in Belgium as a widespread species with high environmental impact. It forms dense, highly competitive thickets, and locally affects the development of ground and shrub layers in forest ecosystems. It may reduce plant species richness, modify the composition of plant communities, or prevent forest rejuvenation (Branquart 2011). In Flanders it is mainly a problem in the sandy region, but it also grows on heavier soils, for instance in the Botanic Garden, where

it has been recorded from fifteen sectors, but always in small numbers.

• *Robinia pseudoacacia*, from North America, was first planted in Europe in the 17th century in a garden in Brussels. By the end of the 18th century it was frequently used in forestry. Nowadays it is mentioned on the watch list of invasive species in Belgium as a widespread species with moderate environmental impact. It is usually found in disturbed areas such as fallow land and roadsides, but has also been reported to invade dry grassland and woodland dominated by light-demanding trees (Branquart 2011). It quickly expands by root suckering and stump sprouting, and forms dense colonies that can out-compete most native plants. It is very common in Flanders and has been recorded from five sectors in the Botanic Garden.

• *Rosa multiflora*, native to Asia, has been recorded from Belgium as naturalized since 1966 (Verloove 2006a). In Flanders it is expanding strongly, although at many of its stations it remains unrecorded. In the Botanic Garden it has been found in one sector with natural vegetation (sector 44). The species is, however, also cultivated in the nursery of sector 40, and could therefore be a collection escape rather than an external neophyte.

• *Sanvitalia speciosa*, an Asteraceae from Mexico, has only recently been introduced as an ornamental plant. It is cultivated as an annual bedding plant or in suspended plant baskets. It is not mentioned in the catalogue of neophytes in Belgium (Verloove 2006a), and no records of possible invasive behaviour have been found in the literature. A gardener from Summit (Massachusets, USA) mentions that it overgrows all other plants, and that even if it dies back in winter (hardiness zone 8b), it resprouts strongly in spring (http://davesgarden.com/guides/pf/go/58763/e). Another species from the same genus, *S. procumbens*, has been cultivated as an ornamental for a longer time and has been described as naturalizing in Belgium (Lambinon *et al.* 2004) and Great Britain (Clement & Foster 1994). In the Botanic Garden a small flowering plant of *S. speciosa* has been found close to the building of the canteen. Some fifty metres away flower baskets containing this species had been suspended to decorate the entrance of the canteen during summer; they had been bought from a commercial firm. Apparently, at least some plants had seeded and escaped from the baskets.

• *Sedum rupestre* is a succulent species that thrives in sunny and dry, nutrient poor sites. It is native to Belgium, but in Flanders most localities have arisen from garden waste, except in the easternmost part, along the Meuse. In the Botanic Garden it has been found in one rather shaded place close to the perimeter, on a spot where it had probably been dumped together with waste from a neighbouring garden. Due to the shaded conditions of this locality, the plant is not likely to survive long.

• *Senecio inaequidens*, from southern Africa, has been introduced in Belgium in 1920. It is listed in the watch list of invasive species in Belgium as a widespread species with moderate environmental impact. It thrives in ruderal and disturbed areas, and may also be found in rock outcrops, open grassland and sand dunes. Its minute achenes are dispersed over long distances, mainly by wind, but also by water and animals (Branquart 2011). In Flanders, where it is common, it is today one of the most strongly expanding species. Within the Botanic Garden it has been recorded from 12 sectors, mainly in the southeastern part of the Domain, from the main entrance to the greenhouses and further up. First recorded in 2003, it has since spread rapidly.

• *Solidago canadensis*, native to North America, is mentioned on the black list of invasive species in Belgium as a widespread alien with high environmental impact. Forming extensive clonal colonies with a high shoot density, it spreads rapidly by vegetative lateral growth. Covering large areas, it can eliminate almost all other plant species (Branquart 2011). In Belgium it is naturalized since the 19th century, and is now rather common in Flanders. However, the distributional data are considered unreliable due to confusion with the similar-looking

S. gigantea, which is also invasive and might actually be more widespread today than *S. canadensis*. In the Botanic Garden *S. canadensis* has been found in the wild in two separate sectors (38 and 68). It is cultivated in the herbetum, and a dwarf form has been planted in and around the orangery garden.

• *Veronica filiformis*, native to the Caucasus region, is naturalized in large parts of Europe and North America. Cultivated as an ornamental plant in rock gardens, it has escaped and settled mainly into lawns. It does rarely set seed in our area but spreads by stem fragments that are transported by lawn mowers (Preston *et al.* 2002). In Flanders it is rather common and still spreading. Within the Botanic Garden it has been found in 36 sectors; no other external neophyte has a higher score. It grows in nearly every lawn. In the 1980s it was often so dominant that lawns turned blue during the flowering period of *V. filiformis*. Herbicides were used for some time in order to control it, but it turned out to be remarkably resistant. During the last decade the species has become less dominant, and is now more scattered within the vegetation. A similar decline after initial massive flowering has also been reported from British populations (Henson 2006).

• *Veronica peregrina*, native to temperate North and South America, is naturalized in parts of Europe and Australia. Already in the 19th century it was recorded from Belgium, but it remained very rare until the 1980s. From then on it has experienced an explosive expansion, so that nowadays it is rather common as a pioneer on moist and open soils. In the Domain it has been found in 23 sectors, usually nurseries and planting areas.

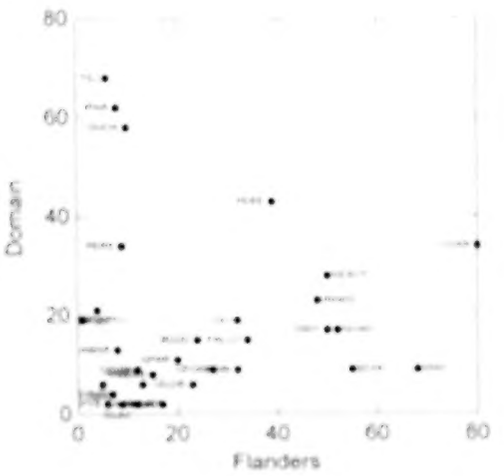


Figure 1 Frequency of neophyte plant species in the Domain (% of sectors) and in Flanders (% of grid squares).

• *Veronica persica*, from West Asia, has spread to all continents except Antarctica. It occurs in similar conditions as *V. peregrina*, and was first recorded from Belgium in 1824. It is now very common in Flanders and has been found in 18 sectors in the Botanic Garden.

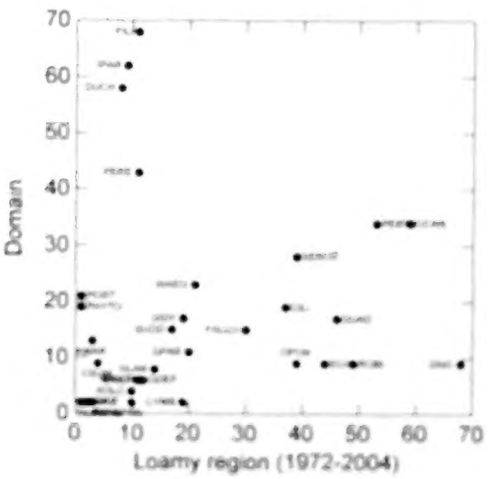
Frequency of neophytes in the Domain and their possible environmental impact

The relative frequency of neophyte species in the Botanic Garden was compared with that outside the Domain. It was expressed as the number of sectors where a species occurs divided by the total number of investigated sectors. We first compared this with the frequency of the species in Flanders. This was found by taking the number of grid units where a species occurs divided by the total number of investigated grid units in Flanders. The data were obtained from Florabank (http://flora.inbo.be//Pages/Common/Default.aspx) for the years 2004-2008, and the average value over these years was computed. The percentage frequency in the Domain was plotted against the percentage frequency in Flanders (figure 1). These frequencies can be compared, keeping in mind that they were taken on very different scales, and that Flemish data are missing for some species (*Cyperus eragrostis*, *Myosotis alpestris*, *Potentilla norvegica*, *Prunus laurocerasus*, *Sanvitalia speciosa* and *Sedum rupestre*).

Figure 1 shows that several neophytes are more frequent in the Botanic Garden than in the whole of the Flemish territory, especially *Veronica filiformis*, *Impatiens parviflora* and *Duchesnea indica*. These species are present in more than half of the sectors in the Domain while they have been recorded in at most 10 % of the grid units in Flanders. Some other species that also are obviously more frequent in the Domain are *Veronica persica*, *Phytolacca*

esculenta and *Portulaca oleracea*. On the other hand, several species are less frequent in the Domain than in Flanders as a whole. These include *Matricaria discoidea*, *Echinochloa crus-galli*, *Conyza canadensis*, *Coronopus didymus* and *Galinsoga quadriradiata*. Some other species where this effect is less pronounced are *Senecio inaequidens*, *Prunus serotina*, *Fallopia japonica*, *Robinia pseudoacacia*, *Oxalis corniculata* and *Oxalis fontana*.

The data that are used in figure 1 represent all Flemish regions, and it can be presumed that there is an effect of the (phytogeographical) region. *Prunus serotina*, for example, is said to thrive more on sandy soils, so it would be logical that it is under-represented in the Domain where only loamy soils are present. That is why we repeated the analysis with data for the loamy region only. The percentage presence of the species in the 4 × 4 km grid squares of the loamy region were taken from the Flemish plant atlas (Van Landuyt *et al.* 2006). This percentage frequency was plotted against the percentage frequency in the Domain (figure 2), yielding a figure that is very similar to figure 1, but with some species being situated differently. This is the case for *Veronica persica* that is now less frequent in the Domain than outside, whereas *Veronica peregrina* is relatively more frequent in the Domain. The low frequency in the Domain of *Robinia pseudoacacia* and *Oxalis fontana* has been accentuated, but it disappears or is mitigated for *Senecio inaequidens* and *Coronopus didymus*.



Figuur 2. Frequency of neophyte plant species in the Domain (% of sectors) and in the loamy region (% of grid squares).

The drawback of the data used for figure 2 is that they span a much longer time period than the mapping period in the Domain, so that this analysis is biased by a time effect. However, by combining the results from both figure 1 and figure 2 we can exclude at least partly the regional and the temporal effects. This leads us to the following conclusion. Three species that are very frequent in the Domain are obviously more widespread inside than outside the Botanic Garden; these are *Veronica filiformis*, *Impatiens parviflora* and *Duchesnea indica*. Two more species that are relatively more frequent in the Botanic Garden are *Phytolacca esculenta* and *Portulaca oleracea*. On the other hand several species are underrepresented in the Domain, namely: *Matricaria discoidea*, *Echinochloa crus-galli*, *Conyza canadensis*, *Galinsoga quadriradiata*, and to some extent also *Robinia pseudoacacia* and *Oxalis fontana*.

If we look at the factors explaining the relative frequency of external neophyte species in the Domain, the availability of suitable habitats for the species is a serious candidate. Among the more frequent species in the Domain, three are woodland species, one is typical for lawns, and the last one is a pioneer species (*Portulaca oleracea*). On the other hand the underrepresented species are all pioneer species, even *Robinia*, which is a woodland species that only thrives in early successional stages and on disturbed locations (Branquart 2011). This seems to reflect the situation in the Botanic Garden, with its relatively many (undisturbed) woodlands and lawns, and probably fewer frequently disturbed sites than outside.

A second factor that could explain the high frequency of some species in the Domain is their dissemination mode. For example, the fact that *Veronica filiformis* is readily transported by lawn mowers explains its high frequency within the Domain.

A third factor that could influence the frequency of the neophytes in the Domain, is the availability of parent material from within the Domain. It is possible that some species we defined as external neophytes, also behave as escapes from the living collections of the Botanic

Garden. This could result in 'wild' populations in a higher number of sectors. This could explain why *Phytolacca esculenta* and *Portulaca oleracea* seem to be overrepresented in the Domain.

The environmental impact of neophytes on the natural vegetations in the Botanic Garden is a matter of concern, since 14 species from the list of 42 external neophytes are mentioned in the invasive species list for Belgium. Of these, 6 species are on the black list, containing species with a high environmental impact. Most of these are classified as A3 (widespread species), and should therefore be monitored closely and controlled if necessary. In decreasing order of frequency within the Domain these are *Prunus serotina*, *Fallopia japonica*, *Impatiens glandulifera*, *Heracleum mantegazzianum*, *Solidago canadensis* and *Fallopia ×bohemica*.

Invasive species with moderate effects on ecosystems are (also in decreasing order) *Impatiens parviflora*, *Duchesnea indica*, *Prunus laurocerasus*, *Senecio inaequidens*, *Buddleja davidii*, *Robinia pseudoacacia*, *Lemna minuta* and *Cyperus eragrostis*. Some of these species should also be watched when they occur in the neighbourhood of rare indigenous species. An example is *Cyperus eragrostis*, which grows close to *Selinum carvifolium*. It can be argued that *Phytolacca esculenta* should also be added to the watch list of invasive species, while it has so far been confused with *P. americana*.

Conclusion

In the National Botanic Garden of Belgium 42 neophytes were found that are presumed to come from external sources (excluding some species of *Cotoneaster* that could not be identified). Most of these external neophytes probably reached the Domain by transportation of seeds or other plant parts by the wind (anemochory) or by animals (zoochory). Possible exceptions are *Sedum rupestre* (probably dumped with garden waste) and *Chamaesyce humifusa* (probably introduced with plants imported from the old Botanic Garden location in Brussels). The three species that occur in the largest numbers of sectors are *Veronica filiformis*, *Impatiens parviflora* and *Duchesnea indica*. These are also more frequent within the Domain than outside, while some other species are relatively underrepresented in the Domain.

Fourteen species are listed as invasive in Belgium: six of these are on the black list and eight on the watch list, with one more species that is probably on the watch list. Especially the former species should be monitored and controlled if necessary, so as to preserve the natural vegetation within the Botanic Garden. It should be remembered that some other invasive species in the Domain have not been treated here, because they have been classified in another category, for example the collection escapes; these species are treated in other contributions in this volume.

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References

Allemeersch L. (2006) – Opmaak van volledige floristische inventaris van het Brussels Hoofdstedelijk Gewest en een florakartering. Rapport in opdracht van het Brussels Instituut voor Milieubeheer, Afdeling Groene Ruimten. Meise, Nationale Plantentuin van België.

Bedouet F. (2009) – « Bienvenue chez les ch'tis » ou la liste des principales espèces en extension récente dans le Nord-Pas-de-Calais ou présentes depuis peu aux portes de la région. *Le jouet du vent* **21**: 5.

Beerling D.J., Bailey J.P. & Conolly A.P. (1994) – Fallopia japonica (Houtt.) Ronse Decraene. *J. Ecol.* **82**: 959-979.

Benedi C. & Orell J.J. (1992) – Taxonomy of the genus Chamaesyce S.F.Gray (Euphorbiaceae) in the Iberian Peninsula and Balearic Islands. *In* Oudejans R.C.H.M. & Molero J. (eds), Current Research in the taxonomy of genus Euphorbia L. s.l. (Euphorbiaceae). *Collectanea Botanica* **21**: 9-55.

Branquart E. (ed.) (2011) – Alert, black and watch lists of invasive species in Belgium. Harmonia Version 1-2. Belgian Forum on Invasive Species. [http://ias.biodiversity.be; accessed on 28.01.2011]

Chitka L. & Schürkens S. (2001) – Successful invasion of a floral market. An exotic Asian plant has moved in on Europe's river-banks by bribing pollinators. *Nature* **411**: 653.

Clement E.J. (1998) Phytolacca. *In* Rich T.C.G. & Jermy A.C. (eds.), Plant Crib 1998. London, BSBI.

Clement E.J. & Foster M.C. (1994) – Alien plants of the British isles. A provisional catalogue of vascular plants

(excluding grasses). London, BSBI.

De Beelde T. & Struyve T. (2008) – Karmozijnbes: een nieuwe potentiële pestsoort? *Natuurpunt Focus* **7 (1)**: 28-33.

Dodoens R. (1554) – Cruijdeboeck. Antwerpen, Jan Vander Loe.

Grau J. & Merxmüller H. (1972) – Myosotis. *In* Tutin T.G. *et al.* (eds.), Flora Europaea, vol. 3: 111-117. Cambridge, Cambridge Univ. Press.

Henson R.M. (2006) – Veronica filiformis (Slender Speedwell) decline or rise? BSBI News **103**:34.

Jongepier J.W. & Robbrecht E. (1986a) – Een 'nieuwe' vondst van Euphorbia humifusa in België. *I.F.B.L. Driemaandelijks contactblad* **4 (2)**: 16-19.

Jongepier J.W. & Robbrecht E. (1986b) – Euphorbia humifusa Willd. *Bull. Soc. d'Echange Pl. Vasculaires de l'Europe et du Bassin Méditerranéen* **21**: n° 12316.

Lambinon J., Delvosalle L. & Duvigneaud J. (2004) – Nouvelle Flore de la Belgique, du Grand-Duché de Luxembourg, du Nord de la France et des Régions voisines, 5e édition. Meise, Jardin botanique national de Belgique.

Meerts P. & Tiébré M.S. (2007) – Fallopia ×bohemica est beaucoup plus répandu que F. sachalinensis dans la région de Bruxelles. *Dumortiera* **92**: 22-24.

Preston C.D., Pearman D.A. & Dines T.D. (2002) – New atlas of the British & Irish flora. Oxford, Oxford Univ. Press.

Ronse A. (2005) – Planten in beweging. *Natuur regio NW-Brabant* **31**: 4.

Ronse A. (2011) – 'Botanic garden escapes' from the living collections at the Botanic Garden. *Scripta Bot. Belg.* **47**: 89-111.

Saintenoy-Simon J. & Duvigneaud J. (2002) – Le domaine royal de Laeken. *Adoxa* **34**: 27-31.

Saintenoy-Simon J., Godefroid S. & Verhelpen B. (1995) – Groupe Flore Bruxelloise. Notes floristiques relatives à la Région de Bruxelles-Capitale (1991-1993). *Adoxa* **6-7**: 27-37.

Stace C. (2001) – New Flora of the British Isles. Second edition. Cambridge, Cambridge Univ. Press.

Sukopp H. (2006) – Botanische Gärten und die Berliner Flora. *Willdenowia* **36**: 115-125.

Van der Meijden R., Plate C.L. & Weeda E.J. (1989) – Atlas van de Nederlandse flora, deel 3. Leiden, Rijksherbarium/Hortus Botanicus.

Verloove F. (2006a) – Catalogue of neophytes in Belgium (1800-2005). *Scripta Botanica Belgica* **39**. Meise, National Botanic Garden of Belgium.

Verloove F. (2006b) – Cyperus eragrostis (Cyperaceae): historiek en huidige status in België. *Dumortiera* **89**: 7-11.

Van Landuyt W., Hoste I., Vanhecke L., Van den Bremt P., Vercruysse W. & the Beer D. (2006) – Atlas van de flora van Vlaanderen en het Brussels Gewest. Brussel & Meise, INBO, Nationale Plantentuin van België & Flo.Wer.

Scripta Botanica Belgica **47**: 89-111 (2011)

'Botanic garden escapes' from the living collections at the Botanic Garden

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Résumé. – Les espèces échappées des collections de plantes vivantes du Jardin botanique national de Belgique. Dans le Domaine 156 espèces de plantes échappées des collections botaniques ont été trouvées. Chaque espèce est brièvement traitée dans le texte, reprenant son aire de répartition originale et secondaire, sa situation en Belgique, et sa présence dans le Domaine. A peu près un quart des espèces est indigène dans notre pays. Parmi les néophytes 9 espèces sont reprises sur la liste belge des espèces invasives, tandis que un tiers des espèces n'a pas encore été signalé en Belgique, bien que 95% soit mentionné comme néophyte ailleurs. Le nombre de plantes échappées est souvent restreint, mais dans certains cas il dépasse la centaine ; souvent les plantes échappées sont éliminées endéans l'année pendant l'entretien du jardin. Certaines espèces s'établissent à une distance d'un kilomètre ; il n'y a pas d'indications de plantes échappées en dehors du Domaine.

Samenvatting. – Collectievlieders uit de levende collecties van de Nationale Plantentuin van België. In het Domein werden 156 plantensoorten aangetroffen die zich verspreid hebben uit de botanische collecties. Elke soort wordt kort besproken aan de hand van haar oorspronkelijk en secundair areaal, haar status in België, en haar voorkomen in het Domein. Ongeveer een kwart is inheems. Van de exoten staan 9 soorten op de Belgische lijst van invasieve soorten, maar een derde van de soorten was nog niet eerder waargenomen in ons land, hoewel 95% hiervan in het buitenland wel als neofyt voorkomen. De plantenaantallen zijn meestal beperkt, maar overschrijden honderd in enkele gevallen; vaak worden ze binnen het jaar verwijderd bij het onderhoud van de tuin. Sommige soorten vestigen zich op een km afstand, er zijn momenteel geen aanwijzingen van vestiging buiten het Domein.

Introduction

'Garden escapes' are defined as plants that have originated from cultivated plants in gardens and that grow outside their planting area. Like other alien plants, most of the garden escapes will remain ephemeral and are then called casual aliens or adventives. In some cases, however, they can become established and propagate themselves, and then they are called naturalized. Some of the naturalized species can even become invasive species that negatively influence agricultural land and/or threaten natural habitats. Garden escapes are a large category of alien species both in number of species as in their ecological impact. More than half (56%) of the 36 plant species that occur on the list of the one hundred worst invasive organisms of the world belong to this category (Lowe *et al.* 2000). In Australia 66% of all plant species that have become naturalized are garden escapes, and this portion is increasing (Groves *et al.* 2005).

The source of garden escapes might be private or public gardens, as well as plant nurseries, and collections in botanic gardens. Several examples are known of alien weeds that have escaped from botanic garden collections and have become naturalized, e.g. *Senecio squalidus* in Great Britain (Kent 1956). Recently the

significant role of botanic gardens in the dissemination of invasive species worldwide has been highlighted by Hulme (2011).

In this contribution the results are given of a survey of the garden escapes from the botanical collections that have been found in the Domain of the National Botanic Garden of Belgium. The dataset we use is the result of observations by the author between 2002 and 2010 (Ronse (2011a); it further includes species observed in the central courtyard of the herbarium building by Hoste & Geerinck (2011). It does not include the deliberately introduced species in the park areas and (semi-) natural areas of the Domain, even if these species further propagate themselves; these plants are discussed in the contribution on stinsen plants and other deliberate introductions (Ronse 2011b). Other neophytes that have probably originated from a source outside the Domain are treated by Ronse (2011c).

For several plants that were found within the Botanic Garden, there is some doubt about their origin. For example, a number of garden escapes are alien species, but others are native, since many native species are cultivated in the collections. In the latter case the distance between the 'wild' plants and the collections containing the species is of crucial importance to determine whether it is a garden escape or not. Doubt persists, and some species are probably present from both origins. For the alien species there can also be doubt about the origin of the plants, while some also grow as neophytes in the area surrounding the Domain. In this case their distance to the collections as well as the frequency of the species outside the Domain has been taken into account.

Results

In total 156 plant species are considered collection escapes in the Domain, which represents about one quarter (26 %) of all species encountered. They are listed in table 1, except for two unidentified species of *Cotoneaster* and a Fabaceae that is probably a non-indigenous *Melilotus*. The table lists the species, indicates whether they are native to the region around Meise, and whether they are mentioned in the list of invasive species in Belgium (Branquart 2011).

Table 1. Collection escapes in the Domain of the National Botanic Garden in Meise. N: native [×: native to the loamy region; (×): native to Flanders outside the loamy region]; **F**: first record from Belgium; **I**: invasive; BL: black list; WL: watch list.

Species	N	F	I
Acer saccharinum			
Adlumia fungosa		x	
Aesculus parviflora		x	
Aethusa cynapium	x		
Agrimonia eupatoria	x		
Agrimonia repens			
Ailanthus altissima			BL
Alchemilla mollis			
Allium schoenoprasum			
Allium spaerocephalon		x	
Amaranthus albus			
Ambrosia artemisiifolia			WL
Ammi visnaga			
Amorpha californica		x	
Anthemis arvensis	x		
Apera spica-venti	x		
Aquilegia vulgaris			
Asarina procumbens		x	
Aucuba japonica			
Barbarea verna	x		
Betula raddeana		x	
Borago officinalis			
Brassica juncea			
Bunias orientalis			
Caragana arborescens		x	
Cardaminopsis arenosa			
Carex vulpina	x		
Catalpa x erubescens			
Catapodium rigidum	(x)		
Cercidiphyllum japonicum		x	
Chaenorrhinum minus	x		
Chelidonium majus	x		
Chenopodium glaucum	x		
Chionodoxa forbesii		x	
Clerodendron trichotomum			
Conium maculatum	x		
Cornus sericea			BL
Cotoneaster bullatus	x	x	
Cotoneaster affinis		x	
Cotoneaster amoenus		x	
Cotoneaster dielsianus			
Cotoneaster nitens		x	
Cotoneaster divaricatus			
Cotoneaster franchetii			
Cotoneaster moupinensis		x	
Crassula helmsii			BL
Crepis biennis	x		

Cyclanthera brachystachya		x	
Cynanchum louisae			
Cyperus congestus			
Dianthus carthusianorum			
Diospyros lotus		x	
Diospyros virginiana		x	
Dipsacus pilosus			
Doronicum pardalianches	(x)		
Elymus caninus	x		
Euphorbia helioscopia	x		
Euphorbia peplus	x		
Fagopyrum esculentum			
Foeniculum vulgare			
Fraxinus ornus			
Fumaria capreolata	x		
Fumaria officinalis	x		
Fumaria parviflora	x		
Galium mollugo	x		
Galium verum	x		
Gymnocladus dioicus		x	
Heliotropium europaeum			
Helleborus foetidus			
Helleborus sp.			
Heracleum mantegazzianum			BL
Hieracium islandicum		x	
Hieracium pilosella	x		
Hirschfeldia incana			
Inula helenium			
Juglans mandshurica		x	
Juglans regia 'laciniata'			
Lamium galeobdolon ssp. argentatum			
Lamium maculatum var. maculatum	(x)		
Lappula squarrosa			
Lavandula angustifolia			
Leycesteria formosa		x	
Ligustrum ovalifolium			
Linum sp.			
Liriodendron tulipifera			
Lonicera nitida			
Lonicera x purpusii		x	
Lysichiton americanus			WL
Lythrum hyssopifolia			
Mahonia aquifolium			BL
Malus sargentii		x	
Malva sylvestris	x		
Melissa officinalis			
Mentha x piperita			
Mentha pulegium	(x)		
Mentha x villosa			
Misopates orontium	x		
Modiola caroliniana			
Morus sp.(M. rubra?)			
Nicandra physalodes			
Nothofagus obliqua		x	
Nothoscordium gracile		x	
Oenanthe pimpinelloides	(x)		
Oxybaphus nyctagineus		x	
Panicum capillare			
Panicum miliaceum			
Parietaria judaica	(x)		
Paulownia tomentosa			
Persicaria lapathifolia	x		
Phacelia tanacetifolia			
Phuopsis stylosa			
Physocarpus opulifolius			
Pinus strobus		x	
Plantago coronopus	(x)		
Plantago media	x		
Platanus x hispanica			
Poa compressa	x		
Populus nigra	(x)		
Potentilla reptans	x		
Prunus lusitanica			
Pterocarya stenoptera			
Quercus rubra			WL
Ranunculus lingua	x		
Ranunculus parviflorus			
Rhus chinensis		x	
Rhus glabra		x	
Rhus typhina			WL
Rubus laciniatus			
Rubus xanthocarpus		x	
Sambucus ebulus	x		
Saponaria officinalis	x		
Sedum album	(x)		
Setaria pumila	x		
Silybum marianum			
Sisymbrium austriacum			
Solanum citrullifolium		x	
Spiraea sp.			
Sporobolus indicus			
Tetradium daniellii		x	
Tetragonia tetragonioides			
Thuja sp.			
Triticum sp.			
Ulex sp.	?		
Valerianella locusta	x		
Verbascum nigrum	x		
Verbena bonariensis			
Verbena canadensis		x	
Vernonia fasciculata		x	
Viburnum plicatum		x	
Viburnum x rhytidophylloides		x	
Vicia faba			

Thirty three species are locally native and some nine more species are native to other parts of Flanders, which makes somewhat more than a quarter of all garden escapes. Of these, ten have not only been recorded as garden escapes, but also as truly native species. Plants observed in the vicinity of cultivated specimens are considered as escapes on these specific sites.

Of the garden escapes nine species are known as invasive alien species in Belgium,

this is 8 % of the alien garden escapes in the Botanic Garden. These are: *Ailanthus altissima*, *Ambrosia artemisiifolia*, *Cornus sericea*, *Crassula helmsii*, *Heracleum mantegazzianum*, *Lysichiton americanus*, *Mahonia aquifolium*, *Quercus rubra* and *Rhus typhina*. Five of these are on the black list (marked 'BL'), the others are on the watch list (marked 'WL').

Some garden escapes have not been mentioned in table 1: they have a tendency to escape from their plant bed, yet they remain within a distance of 3 m or less from the cultivated plants. This is the case for several species that are grown in the herbetum, such as *Artemisia vulgaris*, *Asclepias syriaca*, *Calandrinia umbellata*, *Corrigiola littoralis*, *Herniaria glabra*, *Hyoscyamus albus*, *Lathyrus linifolius*, *Muscari comosum*, *Neslia paniculata*, *Prunella grandiflora*, *Scleranthus annuus*, *Spergula arvensis* and *Spergularia rubra*.

All the species are shortly discussed in the following text. The species that have not previously been recorded as a neophyte in Belgium are indicated **in bold**. First their original distribution is mentioned, and for alien species, also the area where they have been recorded as a neophyte. Their distribution as neophyte relies on data in the Global Compendium of Weeds (http://www.hear.org/gcw), unless otherwise stated in the text. Their status in Belgium has been checked in the Flemish plant atlas (Van Landuyt *et al.* 2006) and in the catalogue of neophytes in Belgium (Verloove 2006). The third point that is mentioned is their occurrence in the Domain of the National Botanic Garden of Belgium, including their proximity to cultivated specimens.

• *Acer saccharinum* (Aceraceae) is a maple native to eastern North America. It has not been mentioned as neophyte in Belgium by Verloove (2006), but has been recorded in three locations in Flanders according to the plant database Florabank (http://flora.inbo.be//Pages/Common/Default.aspx). In Great Britain seedlings of the species have also been observed (Clement & Foster 1994). Young seedlings have also been found in the Domain, at a distance of 20 m from trees that have been planted in 1982.

• ***Adlumia fungosa*** (Fumariaceae) is a biennial climbing plant from north-eastern North America that is threatened or endangered throughout its range. It is apparently naturalized in south-western British Columbia, was reported to be "freely escaping" from a garden in Alberta, and is a casual escape (usually not persisting) elsewhere in Canada (http://www.eflo ras.org/florataxon.aspx?flora_id=1&taxon_ id=233500029). In Meise it grows as a weed in an unheated wall greenhouse, and is furthermore cultivated in two collections outside.

• ***Aesculus parviflora*** (Hippocastanaceae) is a shrub or low tree native to the south-eastern part of the United States. It is sometimes planted in parks and gardens. In Hungary it has been recorded as ephemeral escape (Botond & Zoltan 2004) and in Great Britain a few locations are known where it is suckering extensively (Clement & Foster 1994). It is not mentioned in Verloove (2006). In the Botanic Garden a dozen several years old seedlings have been found in a wooded sector, at a distance of nearly 200 m from the two localities where *A. parviflora* is cultivated.

• *Aethusa cynapium* (Apiaceae) is a native species that has only been found in two sectors at 100 and 350 m from the cultivated plants in the herbetum. However, it could also be present as a truly indigenous species.

• *Agrimonia eupatoria* (Rosaceae) is a native species recorded from several different localities in natural vegetation in the Domain. It also grows in lawn borders in the herbetum, up to 30 m from its planting bed. On this spot it is presumed to be a garden escape from the nearby collections.

• *Agrimonia repens* L. is native to temperate parts of Asia. It has been cultivated formerly as a garden plant, and has become naturalized in different parts of Europe (Tutin *et al.* 1968). In Belgium it has been found in the south of the country as a casual neophyte before 1827, but not since then (Verloove 2006). In the herbetum, this species has escaped and grows in the lawns at a distance of several metres from the planting area.

• *Ailanthus altissima* is a large tree from the family Simaroubaceae that is native to China.

A fast-growing pioneer, it is an often planted tree which is becoming increasingly common, especially in urban areas. In some German cities it is strongly invasive, and in Dutch cities the spread of this tree has become unstoppable since 1996 (Denters 2004). The same has happened in Flanders, where the recently accelerating naturalization process is mainly restricted to cities (Van Landuyt *et al.* 2006). It can invade several types of ecosystems and displaces native vegetation due to its rapid growth, root suckering and an allelopathic toxin that inhibits the growth of other plants, and has therefore been blacklisted in Belgium as an invasive species with high ecological impact but restricted range (Branquart 2011). In the Botanic Garden several seedlings have been found at a distance of more than 10 m from the parent tree.

• *Alchemilla mollis* (Rosaceae) is a herbaceous species from south-eastern Europe and south-western Asia that is often cultivated in gardens. In Flanders, it is a recent and still very rare new garden escape, mainly restricted to urban areas. In the Botanic Garden it has been planted in the herbetum, from where it escapes in lawns but remains in the close vicinity.

• *Allium schoenoprasum* (Alliaceae) is a well-known herb that is probably not native to Belgium and that occurs occasionally as garden escape (Lambinon *et al.* 2004). According to Denters (2004) it is increasingly common in urban areas and along roads, but it is not mentioned in the plant atlas of Flanders (Van Landuyt *et al.* 2006). Verloove (2006) records it as perhaps no more than a casual neophyte in Belgium since the nineteenth century. In the Domain the species has been found in six sectors: in the neighbourhood of the castle lane on one hand, and in the north-western part on the other hand. The species is cultivated in the herbetum and in the walled orangery garden. These locations are not close to the localities of 'wild' plants, which may have originated from external source instead of the collections.

• ***Allium sphaerocephalon*** is cultivated in the herbetum; it is native to the Mediterranean and southern Europe, northwards up to the south of Belgium. It is not native to Flanders. It is naturalized in Britain (Preston *et al.* 2002) and Denmark (Alanen *et al.* 2004). In Belgium it has not yet been recorded as neophyte. In the herbetum tens of plants grow at a distance of up to 10 m from the planting space.

• *Amaranthus albus* (Amaranthaceae) is native to North America. In Belgium it has been introduced since 1857 and has become naturalized in all parts of the country. Some plants were found in two sectors at 100 m from the sector of cultivation in the herbetum.

• *Ambrosia artemisiifolia* (Asteraceae) is native to North America and is naturalized in Australia and in Europe, mainly in southern parts (Clement & Foster 1994). Since 1885 it has occurred casually in Belgium, mostly introduced with seeds or with wool (Verloove 2006). Nowadays the species is invasive in several European countries. In Belgium this thermophilic species does not seem to form self-sustaining populations; however it is a public health hazard as it commonly causes allergies (Branquart 2011). The pollen is very allergenic and contact with the inflorescence can also cause allergic reactions. In the Domain a few plants have popped up in different locations recently, mostly on or along roads. As the species has been cultivated in the herbetum, it is suspected that the plants come from this location. The cultivated plants were eradicated in 2007 because of their allergenic properties, but in 2009 and 2010 plants were found some 200 m away. They might also have originated from an external source as from time to time they are also found growing in the region around the Domain.

• *Ammi visnaga* (Apiaceae) is native to the Mediterranean and the Middle East, and naturalized in South America and in Australia. It is a casual in Flanders and Wallonia since 1880. In the Domain it grows in the medicinal garden, where it escapes at a distance of up to 5 m from the planting area.

• ***Amorpha californica*** (Fabaceae) is a shrub native to the south-western United States and northern Mexico. It has not been recorded as an alien yet, unlike *A. fruticosa*, which is known as a casual horticultural escape in Belgium since the second half of the 20th century. In the Domain seedlings of *A. californica* have been

found in the fruticetum at a distance of up to more than 5 m away from the shrubs that are cultivated since 1953.

• *Anthemis arvensis* (Asteraceae) is native to most of Europe, West Asia and North Africa, and is listed as a federal noxious weed in the US. The species is also cultivated for its ornamental value. In Belgium it is an archaeophyte that formerly occurred as weed in arable fields in the loamy region. It has strongly declined in Flanders, where it has become rather rare (Van Landuyt *et al.* 2006). In the Domain several plants have been found along the perimeter road close to the Plant Palace in 2004 (herb. *A. Ronse* 603). *A. arvensis* had been sown close to this locality in 2003, together with other (former) weeds of arable fields, such as *Centaurea cyanus*, *Papaver rhoeas*, *Vicia cracca* and *Agrostemma githago*. It is also cultivated in the herbetum. In 2010 the species was still present in four sectors, up to 250 m away from the herbetum.

• *Apera spica-venti* (Poaceae) often occurs as a weed in arable fields, but also sometimes as a casual adventive (Van Landuyt *et al.* 2006). It has been observed at a distance of about 300 metres from the herbetum, where it is grown.

• *Aquilegia vulgaris* (Ranunculaceae) is native in the south of Belgium. Several cultivars of this ornamental species are cultivated in gardens; they occasionally escape from cultivation (Lambinon *et al.* 2004). In the Domain seedlings are found in the medicinal garden and in the herbetum, both localities where it has been planted.

• ***Asarina procumbens*** (Scrophulariaceae) is grown as an ornamental in large parts of Europe. The plants have many glandular hairs that make them sticky to the touch. The species has a restricted distribution in southern France and north-eastern Spain, where it occurs at rather high altitudes (Güemes 2009). It is naturalized in Britain, where it thrives on old walls (Briggs 1986; Clement & Foster 1994). In Belgium it has not yet been found as neophyte (Verloove 2006). It grows on the walls of the Balat greenhouse, on the inside and on the outside, and also between the pavements around the greenhouse. This greenhouse stands in the herbetum, where *A. procumbens* has been cultivated since 1986, but it has disappeared from its planting area since several years. The species has also been grown for tens of years in a small isolated heated greenhouse with carnivorous plants within the Plant Palace.

• *Aucuba japonica* (Garryaceae, formerly Cornaceae) is an evergreen shrub with bright red berries from eastern Asia that has often been planted in parks and in gardens, especially the forma *variegata* with variegated leaves. It is naturalized in Australia, New Zealand, USA, and some European countries. In Belgium it has been recorded as a casual alien since 1997 (Verloove 2006). Within the Domain small and larger seedlings have been found in two sectors where this species is planted, but also in some other sectors further away from the cultivated specimens.

• *Barbarea verna* (Brassicaceae) is native to southwest Europe. Since 1977 it occurs as neophyte in Flanders, where it is very rare, with the scattered locations usually situated along road and railroad verges as well as in plantations. In Meise several plants grow on the old walls and the courtyard of the 'Flemish farm' near the main intrance of the Domain. As this species is cultivated in the herbetum, the plants could be considered as garden escapes, although they must have bridged a distance of about 800 m in that case.

• ***Betula raddeana*** (Betulaceae) is a tree that is native to Russia and Georgia, and is a threatened species mentioned on the red list of IUCN (Firsov 1998). It is cultivated in sector 42 where it seeds itself.

• *Borago officinalis* (Boraginaceae) is native to Europe, Africa and temperate parts of Asia. It is a casual escape from horticulture since the 19th century in Belgium. Within the Domain it is cultivated in the herbetum and in the medicinal garden, but it has also been found at the opposite side of the Domain, close to the main entrance. It is occasionally also found along arable fields in the surroundings (Meise Kapellelaan, 2008 and 2009, pers. obs. AR).

• *Brassica juncea* (Brassicaceae) is native to Asia and Africa and a casual in Belgium since

the 19th century. It has been found once in the Domain, not far from the herbetum where it is cultivated.

• *Bunias orientalis* (Brassicaceae) seeds itself in planting areas of other species in the herbetum. Originally from East Europe and West Asia, it is naturalized in West Europe and occurs as such in southern Belgium.

• ***Caragana arborescens*** (Fabaceae) is native to Siberia and parts of China and neighbouring Mongolia and Kazakhstan (Yinxin *et al.* 2010). It is commonly grown as a landscaping plant and ornamental. According to the Global Compendium of Weeds (http://www.hear.org/gcw/) it is naturalized in the USA, an environmental weed in Canada, and a casual cultivation escape in many European countries (Austria, Great Britain, Denmark, Finland, Hungary, Ukraine). In the Domain numerous seedlings have been found close to both localities where it is cultivated. It is not mentioned in Verloove (2006).

• *Cardaminopsis arenosa* (Brassicaceae) is native to large parts of Europe, mainly Central and East Europe. Its distribution range reaches the southern part of Belgium. In Flanders it is rare and has probably been introduced with ore (Van Landuyt *et al.* 2006). In the Botanic Garden this pioneer species has only been recorded once, on a soil heap around the Plant Palace. It has most likely spread from the herbetum some 100 m away, where it is cultivated.

• *Carex vulpina* (Cyperaceae) is a sedge species native to Flanders, where it is very rare. Every year several seedlings of this species are found in the vicinity up to 10 m away from the containers where it is grown, but they are weeded.

• *Catalpa ×erubescens* (Scrophulariaceae) is a hybrid of *C. bignonioides* (from south-eastern USA) and *C. ovata* (from China). Both species have been cultivated since the nineteenth century, especially *C. bignonioides*, and the hybrid has spread all over North America; it is furthermore naturalized in Japan, New Zealand and Australia, and is a neophyte in several Central-European countries (http://www.hear.org/gcw/species/catalpa_bignonioides/). Since 1999 it has been reported from Belgium (Verloove 2006). Several years old seedlings of *C. ×erubescens* occur in the Domain in the same sector where a large planted tree stands.

• *Catapodium rigidum* (Poaceae) is an annual from South and West Europe, North Africa and Southwest Asia. In Belgium, that lies in the northern part of its distribution range, it is extremely rare. It occurs as a pioneer species on dry, nutrient-poor grasslands (Van Landuyt *et al.* 2006). It seeds itself several metres from the containers where it is grown in the Domain.

• ***Cercidiphyllum japonicum*** (Cercidiphyllaceae) is a small multi-trunk tree from temperate areas in East Asia that is planted in gardens and parks as an ornamental. In the United States it is naturalized in several states (Rhoads & Klein 1993, Mitchell 1986). It is presumed that seedlings seldom occur because both male and female trees of this dioecious species must be planted near one another. Within the Domain of the National Botanic Garden tens of seedlings have been found in several localities, sometimes close to cultivated specimens but also up to 100 m away. Many specimens of *C. japonicum* of both sexes are present in several sectors of the Domain, some of them planted in 1939, and these trees freely set seed.

• *Chaenorrhinum minus* (Scrophulariaceae), native to Flanders, is rather common along railroads and on ruderal sites. In the Domain it is cultivated in the herbetum, where it has become a frequent weed. It has also occasionally been found in two nearby sectors close to the Plant Palace, and in a plant nursery at the other side of the Domain. It is hypothesized that the species has escaped from cultivation, at least in most of the localities in the Domain, as it is not often found outside the Domain.

• *Chelidonium majus* (Papaveraceae) is native to most parts of Europe and Asia. It is very common in Flanders. In the Domain it has been found in four sectors, where it is considered as a truly indigenous species, except in the herbetum, where it is cultivated.

• *Chenopodium glaucum* (Chenopodiaceae) naturally occurs in many temperate parts of Europe and Asia, and is native to Belgium. It is rather rare in Flanders. In the Domain it has been found some 40 m from its planting area

in the herbetum and also just outside the herbetum. It is thus considered as a collection escape.

• ***Chionodoxa forbesii*** (Hyacinthaceae) is endemic to south-western Turkey. This early flowering perennial species is planted in gardens for its beautiful flowers. It is reported as naturalized in parts of the USA and in the British Isles. Two related species (*C. luciliae* and *C. sardensis*) have also been reported as naturalized or casual aliens from Japan and a few European countries. Whereas *C. luciliae* and *C. sardensis* have been mentioned as neophytes from Belgium, there are no records of *C. forbesii*. In the Domain *C. forbesii* grows at a distance of approximately 30 m from the herbetum, where it is cultivated.

• *Clerodendrum trichotomum* (Verbenaceae), a large ornamental shrub from Japan and China, is planted in gardens and parks. It can form suckers that appear several metres away from the plant. It has been reported as naturalized in the USA (http://plants.usda.gov/) as well as in Great Britain (Clement & Foster 1994), and it has also been recorded several times from Belgium (Verloove 2006). In the Domain the cultivated plants form root suckers at a few metres distance of the plants.

• *Conium maculatum* (Apiaceae) is a poisonous plant that is native to temperate parts of Europe and Central Asia. In Flanders, where it is native, it is rather rare but increasing. It occurs as a neophyte in many parts of the world, including North and South America, South Africa, Australia and New Zealand and islands in the Pacific Ocean; in some regions it behaves as an invasive species in natural areas (Weber 2003). Within the Domain one plant has been found in the lawn in front of the castle, where it was mown before flowering. As the species is cultivated in the herbetum and in the medicinal garden, it is presumed that seeds have come from there and migrated downhill with the rain.

• *Cornus sericea* (Cornaceae) is an ornamental shrub from North America that is cultivated in private gardens and public parks. According to Verloove (*in* Van Landuyt *et al.* 2006) it is a recent addition to the Belgian flora and is rapidly spreading in Flanders. The fruits are eaten by birds that scatter the seeds. The plants also produce stolons and can thus form large clonal colonies. Verloove states that many localities concern less valuable habitats in urban areas, but he fears that the species could invade more natural habitats too. *Cornus sericea* has been blacklisted in Belgium as a species with a still restricted range but with high environmental impact (Branquart 2011). It can indeed quickly cover large areas due to its dense canopy that inhibits the development of the native vegetation. In the Domain it has been planted in two sectors according to the records of the Botanic Garden; their origin and date of introduction is, however, not known. Since 1997 the species is cultivated in the fruticetum, but is has also been observed in six other sectors. Some of these localities concern (semi-) natural areas with natural vegetation, where *C. sericea* shows invasive propensity, such as in the valuable swamp wood of sector 43.

• *Cotoneaster* spp. (Malaceae). In the Domain seedlings of numerous species of *Cotoneaster*, often not flowering, have been found in many sectors. As it is notably difficult to identify plants without flowers and fruits, and as the collections of the Botanic Garden contain many species and cultivars, the determination of the species is often tentative. In total we have identified eight species, namely ***C. affinis***, ***C. amoenus***, ***C. bullatus***, *C. dielsianus*, *C. divaricatus*, *C. franchetii*, ***C. moupinensis*** and ***C. nitens***. Of these, only three (*C. dielsianus*, *C. divaricatus* and *C. franchetii*) have already been reported as neophyte in Belgium by Verloove (2006). Three more species (*C. bullatus*, *C. moupinensis* and *C. nitens*) have been recorded as occasional or frequent escapes from Central Europe (Dickoré & Kasperek 2010). The latter authors state that, despite birds being the most obvious vectors of the seeds, the distance by which most *Cotoneaster* species disperse seems relatively short. In the Domain various distances between the seedlings and the presumed parent plants have been recorded, reaching up to nearly one kilometre. Most seedlings emerging in nurseries and collections are soon removed, but some survive and reach maturity when they grow under the protection

of large trees or natural vegetation. *Cotoneaster moupinensis* is an example of a species that has been found in undergrowth of woodlands.

• *Crassula helmsii* (Crassulaceae), indigenous to Australia and New Zealand, occurs as a weed in the USA and is known as invasive species in several parts of Europe. This plant of moist and humid areas has been introduced in Europe as a pond plant. Growing in the water as well as above the water level, it produces knotted mats of stems that supplant all other species. It is very difficult to control, while even a small piece of stem with a few tiny succulent leaves readily forms a new plant. In Flanders it was still very rare in 2006, but it was expected to rapidly increase in the next few years (Van Landuyt *et al.* 2006). *C. helmsii* is listed on the black list of alien invasive species in Belgium, as it colonises a wide variety of freshwater habitats with various chemistry, has a significant effect on natural habitats, and can rapidly spread (Branquart 2011). In the Domain of the National Botanic Garden plants of this species are present in containers with aquatic plants in two localities. In one of them, the herbetum, the species is cultivated.

• *Crepis biennis* (Asteraceae) is rather common in Flanders, especially in the loamy region. Some plants grow in the edge of sector 44, some tens of metres away from cultivated plants in a nearby sector; they have only been observed after the plantation of the cultivated specimens, and appear to be increasing.

• ***Cyclanthera brachystachya*** (Cucurbitaceae), an annual climbing plant, is native to South America. It has fruits that are usually explosive, the valves rolling back rapidly and expelling seeds, hence its common name 'exploding cucumber'. It has not yet been recorded as neophyte in Belgium. It is cultivated in the Botanic Garden in the herbetum, where plants have been found more than 10 m away from their planting area.

• *Cynanchum louisae* (syn.: *Vincetoxicum nigrum*; Asclepiadaceae) is a perennial herbaceous vine with dark purple to black flowers and large seed pods with wind-dispersed seeds. It is native to the Mediterranean basin, and is naturalized and considered a noxious weed in North America. In North America *C. louiseae* is a threat to native habitats because it crowds out native species (http://en.wikipedia.org/wiki/Cynanchum_louiseae). In Belgium it has been recorded as a casual horticultural escape from the second half of the 19th century until 1950. Within the Domain of the Botanic Garden it has been cultivated since 1958 in one sector, and a self-sown plant has been found at a distance of more than 700 m. It has been growing there for several years among cultivated shrubs, and flowers and sets seed.

• ***Cyperus congestus*** (Cyperaceae), from South Africa, is a perennial plant that grows to a height of 40-100 cm. Each stem may bear two to seven flower heads (inflorescences) that have a characteristic red colour (http://www.iewf.org/weedid/Cyperus_congestus.htm). It is naturalized in Australia, Hawaii, and parts of southern Europe, and has been recorded as a wool alien in Britain (Clement & Foster 1994). In Belgium it has been mentioned as a rare and ephemeral alien (http://alienplantsbelgium.be/content/cyperus-congestus). In the Domain of the Botanic Garden it is cultivated in the herbetum, where several plants grow outside their planting area. The species has also occasionally been found in two other sectors, including a site where soil mixtures for the collections are stored.

• *Dianthus carthusianorum* (Caryophyllaceae) is native to the southern part of Belgium but not in Flanders. Some plants have been found on a path circa 200 m downhill from the herbetum, where the species is cultivated.

• ***Diospyros lotus*** (Ebenaceae) is a tree native to southwest Asia and southeast Europe. It is related to *Diospyros kaki* (kaki or Sharon fruit) and produces edible fruits, called date plums. This tree is naturalized in New Zealand and Japan. It has been recorded as a casual alien in the Mediterranean and Hungary (http://www.hear.org/gcw/species/diospyros_lotus/), but has not been listed as neophyte in Belgium by Verloove (2006). Numerous seedlings have been found in several parts of the fruticetum. In 2000, hundreds of seedlings grew at distances of up to 70 m from the parent plants, as described by De Meyere (2005). More recently, seedlings

have even been found at a distance of nearly one kilometre. De Meyere suggests that the seeds may have been dispersed by rose-ringed parakeets (*Psittacula krameri*), a tropical exotic species that occurs in large numbers in the Domain. Groups of birds have been observed feeding on fruit bearing trees. Over the last few years, tens of seedlings have been found within a distance of 5 m of the parent trees.

• ***Diospyros virginiana*** (Ebenaceae) produces edible fruits called persimmons. Native to southern parts of North America, this tree is naturalized in New Zealand. It seeds itself freely and is considered a weed in parts of the United States (http://www.hear.org/gcw/species/diospyros_virginiana/). It is not mentioned as neophyte in Belgium by Verloove (2006). In the Botanic Garden several seedlings were found several metres away from the parent plants.

• *Dipsacus pilosus* (Dipsacaceae) is native but rare in Flanders. It occurs in the loamy region in valleys of the river Zenne. In the Botanic Garden a population of tens of individuals flourished in a forest edge, but many plants were destroyed when tree logs were piled up on that spot. However, the population survived. As the locality is only a few hundred metres away from cultivated plants, it is presumed that the 'wild' population originated as garden escapes.

• *Doronicum pardalianches* (Asteraceae), with beautiful yellow flowers, is indigenous to south-western Europe. Flanders lies at the northern limit of its distribution range, and thus it may not be native there. It should perhaps be considered as a stinsen plant of old park estates. In the Botanic Garden the plant has been introduced in several sectors and collections. Some plants grow in adjacent sectors where they have not been planted. We suppose it is a garden escape, since its introduction probably does not date back to the period before the establishment of the Botanic Garden in the Domain.

• *Elymus caninus* (Poaceae), rare in Flanders, has been recorded mainly from the loamy regions in which the Domain is situated. As a forest species it prefers half-shade and occurs in old riverine deciduous woodland, but also along old hedgerows (Van Landuyt *et al.* 2006). Is has been cultivated in the herbetum, but has vanished from its planting area. Now it is growing in the hedge that surrounds the herbetum as well as in two more remote sectors, where it might be indigenous.

• *Euphorbia helioscopia* (Euphorbiaceae) is a very common pioneer species on open soils in Flanders. In the Domain it has only been recorded as a weed from the herbetum, where it is also cultivated.

• *Fagopyrum esculentum* (Polygonaceae) is an annual plant from temperate Asia. It is cultivated as crop plant, in Flanders formerly often on poor sandy soils. Its seeds are used in the same way as cereals (buckwheat). In Belgium it is also known as a bird seed alien. In the Domain some plants were found at a distance of 100 m from cultivated plants.

• *Foeniculum vulgare* subsp. *vulgare* (Apiaceae) is a very aromatic perennial that is used as vegetable (fennel). It is considered indigenous to the shores of the Mediterranean, but it is widely naturalized in many parts of the world, e.g. in Belgium since the nineteenth century. Plants of this species germinate throughout the herbetum, where it is cultivated.

• *Fraxinus ornus* (Oleaceae) is a tree native to southern Europe and south-western Asia. It is frequently grown as an ornamental tree in Europe north of its natural distribution range. It is known in Belgium as a casual escape from horticulture. In the Domain only one plant has been found growing in the central courtyard of the herbarium building, which is several hundred metres away from the nearest cultivated trees.

• *Fumaria capreolata* (Fumariaceae) is native to Flanders, where it occurs mainly in the loamy region. It is, however, a very rare species. One plant has been found at the eastern perimeter of the Domain. It has been considered as truly indigenous, but several plants have also been found in the herbetum, close to the area where the species is cultivated.

• *Fumaria officinalis* (Fumariaceae), common in Flanders, is a weed of arable fields and

places where the soil has been disturbed. It is cultivated in the herbetum, and occurs as weed in nearby parts of the herbetum.

• *Fumaria parviflora* (Fumariaceae) is found as a weed in the herbetum. It is not cultivated there, but has been formerly cultivated in other collections of the Botanical Garden (Ronse & Groom 2011). It has always been very rare in Flanders and is today considered to be extinct.

• *Galium verum* (Rubiaceae), indigenous to Belgium, sometimes escapes from its planting area in the herbetum. It grows in lawn edges and in planting areas up to more than 50 m away from the cultivated plants. It is rather common in Flanders but rare in the loamy region to the west of Brussels. It's a declining species, typical for rather nutrient poor soils.

• *Galium mollugo* (Rubiaceae) is also native and cultivated in the herbetum, where it has spread into several places in the lawns. It is, however, also found in natural vegetation in other sectors, where it could be truly indigenous.

• ***Gymnocladus dioicus*** (Fabaceae), a large dioecious tree with bipinnate leaves, is native to the eastern USA, and is sometimes cultivated in gardens and parks in Europe. It has been reported as a casual alien in Hungary (http://www.hear.org/gew/species/gymnocladus_dioica/). Within the Domain tens of seedlings were found at a distance of 10 m from planted trees.

• *Heliotropium europaeum* (Boraginaceae) is native to Europe, Asia, and North Africa, and is naturalized in Australia and North America. In Belgium, it has been known as a casual wool alien since the 19th century. In the Domain it escapes from its planting area, but remains within the herbetum.

• *Helleborus* sp. (Ranunculaceae). In the woodland of sector 18 we found a non-flowering *Helleborus*, which we could not identify. Several species of *Helleborus* are cultivated in the Botanic Garden; these include *H. argutifolius*, *H. niger*, *H. orientalis*, and *H. purpurascens*. Two of these species are mentioned in the list of Belgian neophytes (Verloove 2006): *H. niger* (recorded from Flanders in the 19th century only) and *H. orientalis* (from Wallonia).

• *Helleborus foetidus* (Ranunculaceae) has been recorded as escape within the Domain. Native to central and southern Europe and Asia Minor, its distribution range extends into southern Belgium, but not into Flanders. Some plants have been found under a tree, several tens of metres away from the site where it is cultivated.

• *Heracleum mantegazzianum* (Apiaceae) is a tall plant, up to 5 m high, which is indigenous to the Caucasus and central Asia. It has been introduced as an ornamental to Europe in the nineteenth century and has since become a pernicious invasive plant. It has also spread in parts of the United States and Canada. In Flanders it was first recorded from the wild in 1938, but since then it has increased enormously; it is now rather common. It has been listed on the black list of invasive species in Belgium, as a widespread species with high environmental impact. Its height and leaf area enable it to overtop and outcompete most indigenous herbaceous plant species. Besides the ecological problems, the species also represents a health hazard for humans, as the plant exudes a clear watery sap, which contains compounds that cause severe burns to skin (Branquart 2011). In the Domain plants have been found in three sectors, including sectors 51 (seedlings) and 54, where *H. mantegazzianum* is considered as an escape from the botanical collections. These two sectors are situated close to the herbetum, where the species has been previously cultivated, but has been removed because of its invasive character. In the third sector plants have been found along the rivulet, which suggests that they have come from outside the Domain, and are external neophytes.

• ***Hieracium islandicum*** (syn.: *Pilosella islandica*; Asteraceae) is native to Iceland. As far as we know, it has never been mentioned as neophyte from Flanders or anywhere else. It is cultivated in the collections and has spread from the planting area into the surrounding lawn several metres away.

• *Hieracium pilosella* (Asteraceae), from Europe and West Asia, is native to Flanders, where it is common, especially on sandy soils. Within the Domain it has been found in lawns of the herbetum, up to a distance of 75 m away from its planting area, but also in the lawns of sector

67, where it might be indigenous. Outside the Domain it does not occur on many places in the vicinity, as it is less common on loamy soils, but there is one locality about 1 km away.

• *Hirschfeldia incana* (Brassicaceae) is a perennial species from the Mediterranean that has become naturalized in many parts of the world, including Australia, New Zealand, Japan, and parts of North and South America; as casual alien it has been recorded from Scandinavia. In Belgium it has been naturalized since the 19th century. Within the Domain it is found in different parts of the herbetum, where it is cultivated.

• *Inula helenium* (Asteraceae), a tall plant with showy yellow flowers, is native to parts of Europe (mainly Central Europe) and Asia. It is an established escape from cultivation in widely scattered localities throughout the British Isles (Clement & Foster 1994). It is also naturalized in Belgium (Verloove 2006). In regions where it is known as a widespread archaeophyte, such as south-western Hungary, it has given its name to a new vegetation type in forest fringes in wet valleys along alder forests, the *Deschampsia caespitosae-Inuletum helenii* (David 2009). In the Botanic Garden tens of plants thrive along the south bank of the castle lake, a rather wet spot. This locality has existed for a few years, since the banks of the lake are mown less frequently. This population obviously originated from cultivated plants in the herbetum, some 350 m uphill. The plant is easily confused with *Telekia speciosa*, a species that is also grown in the herbetum.

• ***Juglans mandshurica*** (Juglandaceae), with compound leaves up to 90 cm long, is native to China, Korea and the extreme eastern part of Russia. The tree can resist temperatures down to -45°C (http://en.wikipedia.org/wiki/Juglans_mandshurica). It has been recorded as a casual neophyte in Ukraine (Mosyakin & Yavorska 2002). It is not mentioned by Verloove (2006), but seedlings have been found in an arboretum at Tervuren (pers. comm. D. Geerinck). Within the Domain tens of young trees have been found, some of them apparently more than 10 years old; they vary in height from 0.5 m to more than 4 m. Most seedlings grow at a distance of approximately 10 m from the parent tree, on the edge of woodland, but one seedling has been found up to 150 m away. The age of the parent tree is unknown.

• *Juglans regia* (Juglandaceae), from south-eastern Europe and Asia, has been planted for a long time as nut tree in Belgium. However, it did not seed itself until a few decades ago; nowadays it is common in Flanders (Verloove *in* Van Landuyt *et al.* 2006). In the Domain a seedling of the variety '*Laciniata*' has been found at a distance of some 200 m away from a cultivated tree. This seedling shows the incision pattern of the variety. It is probable that squirrels have carried the nuts away, as the seedling stands among conifers where squirrels are often seen.

• *Lamium galeobdolon* subsp. *argentatum* (Lamiaceae) is not native to Flanders (whereas subsp. *galeobdolon* is native and common in deciduous forests). This plant occurs in many forests, where it has become naturalized as a garden escape, often showing a propensity to overgrow native undergrowth. A patch of several square metres has been found in tall, wet vegetation in the Botanic Garden. It probably originated from the neighbouring sector, where plants are cultivated under the name of *L. galeobdolon* var. '*variegatum*'. The same taxon has also been introduced in two other wooded sectors.

• *Lamium maculatum* (Lamiaceae) is native to central and eastern Europe. In Belgium the only natural populations are situated in Wallonia and along the river Meuse in Flanders. It is rare in Flanders, where outside the Meuse area it has been recorded from scattered localities, very probably as garden escape (Van Landuyt *et al.* 2006). Persistent populations or established garden escapes have been recorded from the British Isles too (Clement & Foster 1994). Within the Domain some plants of var. *maculatum* grow in a forest edge. This variety, which has been mentioned as regional stinsen plant by Bakker & Boeve (1985), is also grown in two sectors within the Domain, and thus it is considered as a collection escape here.

• *Lappula squarrosa* (Boraginaceae) is native to temperate parts of Europe and Asia. The

fruits of this annual species are coated with hooked prickles, so that they are inadvertently transported by animals or humans. This may explain why the species has become introduced in many regions outside its native distribution range, such as parts of North America, Europe and Africa. In many areas it's a noxious weed. In Belgium it is a casual neophyte since the 19th century. Within the Domain it is restricted to the herbetum, where it is cultivated.

• *Lavandula angustifolia* (Lamiaceae), native to the western Mediterranean, is known as a persistent garden escape in Britain (Clement & Foster 1994). As casual neophyte it has also been recorded from Flanders since 2000 (Verloove 2006). Within the Domain *L. angustifolia* has been found in two locations, including the enclosed courtyard of the herbarium building. Obviously it has reached the courtyard from the terrace of the fourth floor of the building, where it was cultivated as a container plant. A second location is close to the building containing the canteen, close to a site where five different cultivars are cultivated.

• ***Leycesteria formosa*** (Caprifoliaceae) is a deciduous shrub native to the Himalaya and south-western China. It is naturalized in parts of the United States, Great Britain, New Zealand and Australia, where it is considered invasive. It has not been recorded as neophyte from Belgium. Within the Domain one flowering and fruiting specimen was found on a pile of stones on a courtyard, some 10 m away from cultivated plants. It is assumed that seeds have been brought there by birds that eat the berries.

• *Ligustrum ovalifolium* (Oleaceae) is a shrub resembling the native *L. vulgare*; both species are often planted in hedges. *L. ovalifolium* is native to Japan but has become naturalized or is found as a casual alien in Australia, New Zealand, South Africa, the USA and several different regions in Europe (including Flanders). Within the Botanic Garden seedlings have been recorded from nine sectors. The species has been cultivated in four sectors since the early days of the Botanic Garden in Meise, and the cultivars 'Argenteum' and 'Aureum' are also represented. Some of the locations are more than 250 m away from the nearest cultivated plants. It is likely that the seeds are dispersed by birds that eat the seeds.

• *Linum* sp. (Linaceae). A single plant of a non-identified *Linum* has been found some 200 m downhill from the herbetum, where three species of this genus are cultivated: *Linum flavum*, *L. tenuifolium* and *L. usitatissimum*. The latter species occurs frequently in Belgium as casual neophyte escaped from agriculture.

• *Liriodendron tulipifera* (Magnoliaceae), a large tree originally from eastern North America, is planted in gardens and parks. It is naturalized in New Zealand and is a garden escape in Canada. Recently it has also been reported to self-seed in Wisley Gardens in Great Britain (Armitage 2010). In Belgium it has been reported as a casual neophyte in the Brussels region. Within the Domain two seedlings have been recorded from different sectors at a distance of about 100 m from adult trees.

• *Lonicera nitida* (Caprifoliaceae), a small shrub, is native to China. It is used as ground cover and for low hedges. It has been reported as a casual garden escape in Flanders since 2000. It was found growing wild in the inner courtyard of the herbarium building, at more than 50 m from cultivated plants. The seeds have probably been brought in by birds that eat the berries.

• ***Lonicera ×purpusii*** (Caprifoliaceae) is the hybrid between *L. fragrantissima* and *L. standishii*, two winter-flowering shrubs from China. It occurs in the wild where the ranges of the parent species overlap (Buffin 2005). It has been reported as a casual alien in Hungary (Botond & Zoltan 2004) and as a garden escape in Great Britain (Clement & Foster 1994), but so far not in Belgium. Within the Domain, a self-sown shrub has been found in the inner courtyard of the herbarium building, within 50 m of a cultivated specimen.

• *Lysichiton americanus* (Araceae) is native to western North America, where it grows in swamps and wet woods. It is cultivated as ornamental species because of its striking yellow spathe. It is naturalized and considered invasive in various European countries. In the British Isles it is naturalized since 1947, but the majority of sites date from after 1989 (Wil-

son 2003). In Germany it has well-established populations in valuable natural *Alnion* and *Alno-Ulmion* vegetation (Korneck & Krause 1990). The species has been added to the 'alert list' of the European and Mediterranean Plant Protection Organization (EPPO) in 2004. In Belgium it has been placed on the watch list of invasive alien species, due to its moderately high ecological impact but as yet still isolated populations. It can build a dense layer with its huge leaves, excluding light from native species that are usually not adapted to strong shade (Branquart 2011). Within the Botanic Garden this species has been introduced in two (semi-) natural locations (along the orangery lake in sector 21, and near 'De Machoechel' in sector 56) as well as in the herbetum. It has, however, also escaped into three other sectors, in sector 45, along the small lake of sector 18 and along a rivulet in sector 57. Both locations are situated some 100 m or more downhill from the cultivated specimens.

• *Lythrum hyssopifolia* (Lythraceae), native to Europe, has been introduced to and is naturalized in parts of North and South America, Japan, Australia and New Zealand. It's a casual alien in parts of Scandinavia. In Belgium it is a very rare species in the Meuse district. It is probably not native to Flanders, where it has been recorded as neophyte (Lambinon *et al.* 2004). In the Domain it was growing in a humid roadside in sector 43, a few hundreds of metres away downhill from the herbetum, where it is cultivated. The plants have only stood there for one year.

• *Mahonia aquifolium* (Berberidaceae) is a shrub native to the North American west coast. In several regions throughout the world, it has been classified as an invasive alien that can displace native vegetation; in several European countries it is known as either naturalized or a casual alien. It has been planted as an ornamental species for a long time in Europe. In Flanders it has been a casual alien for some time, but recently it has started to naturalize as well. Within the Botanic Garden seedlings have been found on three locations in the vicinity of cultivated plants, and thus they are considered as escapes from the collections.

• ***Malus sargentii*** (Malaceae), native to Japan, has white flowers and small red crab-apples in autumn. It is sometimes considered as a subspecies of *M. toringo* (syn.: *M. sieboldii*), and is then called *M. sieboldii* var. *sargentii* or *M. toringo* subsp. *sargentii*. According to the Global Compendium of Weeds, *M. toringo* is naturalized in the USA, is a cultivation escape in Denmark, and is invasive in Lithuania. It has not been recorded as a neophyte from Belgium. Within the Domain *M. sargentii* is cultivated in three sectors, but plants have been found in five other sectors. Several shrubs are flowering and fruiting in (semi-) natural wooded areas, and plants have also established themselves in the inner courtyard of the herbarium building, some 500 m away from cultivated plants. The seeds are presumably spread by fruit-eating birds.

• *Malva sylvestris* (Malvaceae) is a native plant that is common in Flanders. It is cultivated in the herbetum and in the medicinal garden, where it sows itself. It has been found in a neighbouring sector (probably as a garden escape), but also in a more remote sector (where it might have established spontaneously as a truly indigenous plant).

• *Melissa officinalis* (Lamiaceae), an aromatic plant that is probably native to the Mediterranean, has long been in cultivation as a herb. It is naturalized in Belgium since the eighteenth century (Van Landuyt *et al.* 2006). Within the Domain it has been found in two sectors close to the main entrance, where plants are cultivated, and these plants are considered as garden escapes. It has also been found in the vicinity of other cultivated plants in the herbetum and in the medicinal garden. Finally, plants have also been found in yet another locality.

• *Mentha pulegium* (Lamiaceae) is native to Flanders yet extremely rare. It grows in a number of lawns within the Domain as garden escape (Ronse, in prep.).

• *Mentha ×piperita* subsp. *piperita* (Lamiaceae) is often cultivated as a herb and for its essential oils. It has become naturalized and is considered as a weed in many parts of the world. In Belgium it sometimes escapes from gardens. Within the Botanic Garden it grows

in tall vegetation on wet soil in a forest edge, together with *Cirsium oleraceum*, *Heracleum sphondylium*, *Humulus lupulus* and *Fallopia ×bohemica*. This locality lies approximately 250 m away from the herbetum and the medicinal garden, the sectors where the plant is cultivated.

• *Mentha ×villosa* subsp *villosa* (Lamiaceae) is native to Belgium, especially in the south of the country. It is locally naturalized as a garden escape in Great Britain (Clement & Foster 1994). In Meise it propagates by root suckers and remains within a few metres distance from the cultivated plants.

• *Misopates orontium* (Scrophulariaceae) is fairly rare in Flanders, and has steadily declined. It used to be primarily an arable weed, but is today usually recorded from wasteland. Within the Botanic Garden it was found in sector 54, not far from the herbetum where it was grown from 1987 to 2008. This suggests that the species occurs as a garden escape.

• *Modiola caroliniana* (Malvaceae), from South America, was found as a casual wool alien at the end of the 19th century, having been last recorded in 1906. Within the Domain it is cultivated in the herbetum, where it has also been found some metres away from the cultivated plants.

• *Morus* sp. (Moraceae). A *Morus* seedling has been observed in a wooded area in the north of the Domain. Three different species of mulberry are cultivated in the Botanic Garden: *M. alba*, *M. nigra* and *Morus rubra*. The closest cultivated species is *M. rubra* (from the USA), at a distance of several hundreds of metres. Verloove (2006) only mentions *M. alba* as a casual recorded before 1850. This species has been introduced in several parts of the world, and shows invasive behaviour in natural habitats in South Africa (Weber 2003).

• *Nicandra physalodes* (Solanaceae), from South America, is a rare neophyte in Belgium. It is cultivated in the herbetum, from where it has escaped, partly staying within the herbetum, but also growing in two other sectors up to more than 500 m away.

• ***Nothofagus obliqua*** (Fagaceae), from Chile and Argentina, is planted as deciduous timber tree, as it is valued for its fast growth and high hardwood quality. It grows on many types of soils and sets seed freely. It is naturalized in Britain (Preston *et al.* 2002), but had not yet been recorded from Belgium. Within the Domain one seedling was found at a distance of approximately 300 m from cultivated plants that were planted in the Botanic Garden in 1983.

• ***Nothoscordum gracile*** (syn.: *N. borbonicum*; Alliaceae) is native to South America, and is widely naturalized as an almost cosmopolitan weed. It seeds freely and forms bulblets that are very difficult to eradicate. It had not yet been recorded as neophyte from Belgium. It is grown in the herbetum, where numerous plants are found up to 20 m away of its planting area, overgrowing other nearby bulbous plants.

• *Oenanthe pimpinelloides* (Apiaceae) has a sub-Mediterranean and South Atlantic distribution. In Belgium, outside its main distribution range, it is extremely rare, and populations have been ephemeral, probably due to the plant's cold sensitivity. Within the Domain *O. pimpinelloides* was found in 2002 in lawns and grasslands of three sectors. These include the herbetum, where it was cultivated since 1983. In 2003 the number of plants in these sectors had increased, and some ten plants were found in a fourth sector (Ronse 2005). Since 2005 all escaped individuals have disappeared, except in the herbetum, where numerous plants thrive in the lawns.

• ***Oxybaphus nyctagineus*** (Syn.: *Allionia nyctaginea*, *Mirabilis nyctaginea*; Nyctaginaceae), native to southern North America, is naturalized (or has at least been recorded as a casual alien) in several Central European countries, and is an agricultural weed in Canada. It has not been recorded as a neophyte in Belgium. Cultivated in the herbetum, it is found as weed between pavements and in planting areas of other species, but also in a collection of trees up to 250 m further away.

• *Panicum capillare* (Poaceae), from North America, has been recorded from Belgium since the nineteenth century. It has been found in three sectors in the vicinity and up to 300 m away from the herbetum, where it is cultivated.

• *Panicum miliaceum* (Poaceae) is native to Central Asia and is cultivated as cereal in (sub-) tropical areas. In Belgium it is usually recorded as an ephemeral alien, with perhaps only very few locally naturalized populations (Lambinon *et al.* 2004). It has been found in two sectors within the Domain, but is cultivated in the herbetum, and we therefore consider it as garden escape.

• *Parietaria judaica* (Urticaceae) is a very rare native species in Flanders, where it mainly occurs in urban areas on walls and between pavements, or along large rivers. It is cultivated in the herbetum but also grows on the paths and between stones in this sector.

• *Paulownia tomentosa* (Scrophulariaceae) is a deciduous tree from China and Japan that is often planted as an ornamental tree. It is considered invasive in the USA, and is naturalized in Australia and New Zealand. In several European countries too it is a naturalized or casual alien. It seeds freely mainly in urban areas and along large rivers, such as the Mosel in Germany. Within the Domain seedlings have been found in the vicinity of cultivated trees, but clusters of seedlings were also found on spots where a layer of mulching had been used, indicating that numerous seeds may have survived in the mulching made from bark and wood chips.

• *Persicaria lapathifolia* (Polygonaceae) has been found in nine sectors in the Domain. One of these places is the herbetum, where the plant is cultivated, and where it might be a garden escape. We presume that in most other localities it should be described as truly indigenous.

• *Phacelia tanacetifolia* (Hydrophyllaceae), native to the south-western USA and northern Mexico, is widely used in agriculture as a cover crop, but also as ornamental plant. It has naturalized in Australia and New Zealand, and in many European countries it has been described as naturalized or as casual garden or agricultural escape. Within the Botanic Garden it has been sown as cover crop, and some plants have been found at a distance of nearly 500 m.

• *Phuopsis stylosa* (Rubiaceae) has its natural range from the Caucasus region to north-western Iran. It is known as a persistent or naturalized garden escape in the British Isles (Clement & Foster 1994), and it also shows a tendency for naturalization in Belgium (Lambinon *et al.* 2004). Within the Domain it is cultivated on two locations, where it has spread several metres from its planting area. Elsewhere in the Domain it has been found at a distance of 400 m from the closest cultivated specimens.

• *Physocarpus opulifolius* (Rosaceae) is a shrub from North America. It is a naturalising garden escape or casual alien in many European countries, including Belgium (Verloove 2006). It has also been reported from the Royal Domain in Laken (Brussels), close to the Botanic Garden, as introduced species with a tendency towards naturalization (Saintenoy-Simon & Duvigneaud 2002). Within the Botanic Garden seedlings have been found in the vicinity of cultivated shrubs. Non-flowering shrubs have been recorded from four more distant sectors, up to at least 300 m from the collections, including undisturbed woody zones. The seeds are probably dispersed by seed-eating birds.

• ***Pinus strobus*** (Pinaceae), native to eastern North America, is naturalized in New Zealand and Australia and in several European countries, but has not been mentioned as neophyte in Belgium before. A young tree, now approximately 20 years old, grows in the central courtyard of the herbarium building.

• *Plantago coronopus* (Plantaginaceae) is a small, native, herbaceous pioneer plant from brackish soils naturally restricted to coastal habitats. It occurs as a neophyte in North and South America, New Zealand, Hawaii, Madagascar and the Mascarenes, and shows invasive behaviour in Australia (Weber 2003). Due to the frequent use of salt on roads in winter, it has recently invaded roadsides in the interior of Belgium. It is grown in the collections of the herbetum and has escaped into the lawns.

• *Plantago media* (Plantaginaceae), native to Belgium, grows in grassland on calcareous or basic soils. It is rare in Flanders and has been recorded from roadsides near Brussels (Van Landuyt *et al.* 2006). It is cultivated in the herbetum where it escapes into the lawns, but has not been found elsewhere in the Domain.

• *Platanus ×hispanica* (syn.: *P. ×acerifolia*; Platanaceae) is considered to be the hybrid of *P. orientalis* (from the Mediterranean) and *P. occidentalis* (from North America). This tree is frequently planted in towns along lanes or in parks, as it is very resistant to air pollution. It has been planted in Belgium for a long time, yet seedlings have been reported since 1985 only. Within the Domain a few several years old seedlings have been found in three locations, at distances of between a few metres to one hundred metres from the nearest trees. The large trees have probably been planted during the laying out of the Botanic Garden in Meise.

• *Poa compressa* (Poaceae) has been found only once in the Domain at a distance of 200 m from the herbetum, where this native species is cultivated, and is therefore considered a garden escape.

• *Populus nigra* (Salicaceae) is a cultivated species of which seedlings have been found casually in Flanders. Within the Domain a few trees have grown spontaneously from seed and developed in the inner courtyard of the main building; they must be nearly 20 years old. The nearest cultivated trees of this species are 600 m away, though a specimen of var. *italica* grows at a distance of 250 m.

• *Potentilla reptans* (Rosaceae), widespread and native to Belgium, is cultivated in the herbetum, and grows as escape up to 15 m away from the planting area.

• *Prunus lusitanica* (Amygdalaceae; often included in Rosaceae) is an evergreen tree native to south-western Europe, Morocco and Macaronesia. Planted as ornamental tree, it is naturalized in Australia and New Zealand, parts of the USA, and in several European countries. In the British Isles it is naturalized in widely scattered locations in woodlands, and forms dense stands in the Killarney district (Ireland) (Clement & Foster 1994). In Flanders there is a single record from 2001 as casual neophyte (Verloove 2006), to which I can add a record from my own garden in Opdorp (IFBL D4.33.21) where the trees regularly sow themselves up to several metres away from the parent plants. Within the Botanic Garden small seedlings have been found close to a large tree near the main entrance. In another sector, at a distance of 100 m, several young trees grow in undergrowth of mixed woodland, some plants over two metres high and probably more than 10 years old.

• ***Pterocarya stenoptera*** (Juglandaceae), a tree native to China, is naturalized in Japan and in the USA, but it has not been mentioned as neophyte from Europe. It is closely related to and very similar to *P. fraxinifolia*, a species from the Caucusus and Iran that is frequently planted in parks; in *P. stenoptera*, the rachis of the pinnately compound leaves is winged. *P. fraxinifolia* is known as a neophyte in Europe. It is a naturalized escape from cultivation in Great Britain and in Belgium and north-western France, where it colonises riparian habitats (Verloove 2011). The hybrid between both species, *P. ×rehderiana*, has also been recorded as a casual neophyte from Belgium. Most species of *Pterocarya* also spread by forming root tillers. In the Botanic Garden *P. stenoptera* is planted in the fruticetum, where it sows itself up to a distance of several tens of metres from the parent trees. However, in 2010 hundreds of seedlings have been found at a distance of nearly 500 m. A thick layer of mulch of local origin has been spread there, and it is presumed that this mulch contained numerous seeds of *P. stenoptera*.

• *Quercus rubra* (Fagaceae) is native to North America, but has been introduced in Europe in the 18th century. It is cultivated for its timber and as park tree. In the northern part of Belgium, where it is very common, especially on sandy soils, it displays invasive behaviour and threatens the native flora (Van Landuyt *et al.* 2006). Within the Botanic Garden it has been planted in six sectors; seedlings have been observed in three of these, but also in four other sectors.

• *Ranunculus lingua* (Ranunculaceae), native to Belgium, is a very rare and declining species in Flanders. It is often planted in garden ponds and is increasingly found naturalized in the wild (Van Landuyt *et al.* 2006). Within the Domain it has been observed a few metres away from the containers in which it is cultivated.

• *Ranunculus parviflorus* (Ranunculaceae) is a non-native species that was formerly cultivated in the collections of the Botanic Garden, where it has dispersed and become a naturalized species (Ronse 2011d).

• ***Rhus chinensis*** (Anacardiaceae), also called Chinese sumac, is a shrub from East Asia. It is cultivated in the medicinal garden, where several rather large seedlings grow in the neighbourhood of the cultivated plants. No information has been found on the occurrence of this species as neophyte.

• ***Rhus glabra*** (Anacardiaceae), from North America, is closely related to the frequently cultivated *R. typhina*. It is considered an (environmental) weed in many parts of the USA and Canada and is naturalized in Australia. It does not seem to occur as a neophyte in Belgium, contrary to its hybrid with *R. typhina* (*Rhus ×pulvinata*), which has been recorded as casual (Verloove 2006). Within the fruticetum seedlings of *R. glabra* grow in the vicinity of the cultivated plants.

• *Rhus typhina* (Anacardiaceae), from North America, is the most frequently cultivated species of the genus in Belgium. This dioecious shrub not only propagates by seeds, but also through sprouting from spreading rhizomes. This may result in dense, aggressively growing colonies. It is naturalized in Australia and New Zealand, and in various European countries, including Belgium. Numerous saplings have been found in the Domain, up to tens of metres away from the cultivated plants.

• *Rubus laciniatus* (Rosaceae) has deeply incised leaflets and grows to a height of 3 m. It is native to parts of Europe and is naturalized in Australia, New Zealand, the USA and several European countries. In Belgium it has become naturalized since more than fifty years. In Flanders it is still very rare but rapidly increasing. Its seeds are dispersed by birds. In the Domain non-cultivated plants have been found in one locality rather close to cultivated plants, and also in some five more sectors further away. As the species is still very rare in Flanders, and as escaped plants have been found in a sector close to cultivated specimens, we suppose that these plants have escaped from the living collections.

• ***Rubus xanthocarpus*** (Rosaceae), a blackberry with trifoliolate leaves and edible yellow to orange berries, is native to western China. It is naturalized in Poland and the Czech Republic, and is a casual alien in Denmark. It has not been mentioned as neophyte from Belgium. In the wild it usually grows on rocky substrates, and is used as ground cover in gardens. Within the Domain it has been planted in one locality, where more than ten seedlings grow at a distance of several metres.

• *Sambucus ebulus* (Caprifoliaceae), native to Flanders but rare, grows in the wild in the region of Meise. Within the Domain it has been recorded from a forest edge, in a sector adjacent to cultivated plants. Because of the vicinity of cultivated plants, we consider this species to be an escape from cultivation.

• *Saponaria officinalis* (Caryophyllaceae), from Europe and temperate parts of Asia, has long been cultivated for its medicinal properties and for soap production. It is thoroughly naturalized in North and South America, Australia, New Zealand, Japan, and several countries in Europe. In Belgium, where it has been cultivated for a long time, it has become naturalized since the 18th century or even before. Within the Domain it was found in one locality at a distance of more than 50 m from the collections.

• *Sedum album* (Crassulaceae) is native to Flanders but rare. It is known as neophyte in North America, New Zealand and several countries in Europe. In the Botanic Garden it is cultivated in the herbetum, and has spread to a distance of several tens of metres, probably by vegetative propagation.

• *Setaria pumila* (Poaceae) is considered native to Flanders; it is furthermore introduced time and again as alien, often with bird seed. It has been found in two sectors close to the herbetum, where it is cultivated.

• *Silybum marianum* (Asteraceae) is an ornamental thistle with variegated leaves that is also cultivated for medicinal use. Native to the Mediterranean, it has spread as a neophyte throughout most parts of the world, often as an invasive weed (Weber 2003). It has been mentioned as casual neophyte in Belgium since

1803 (Verloove 2006). Within the Botanic Garden it is cultivated in two collections, and seedlings have been observed about 600 m from there, in a sector where one plant has flowered.

• *Sisymbrium austriacum* (Brassicaceae) has its natural range in south-western and central Europe. Three subspecies can be distinguished, but their taxonomical value is subject to discussion (Lambinon *et al.* 2004). At the species level it has been mentioned as neophyte in Great Britain (Clement & Foster 1994). In Flanders subsp. *chrysanthum* mainly occurs along the river Meuse, where it locally forms large populations (Van Landuyt *et al.* 2006). This subspecies probably reached these localities from the Vesdre valley, where it has been introduced as a wool alien since the 19th century. Recent research has shown that it is increasing and has spread over long distances downstream (Jacquemyn *et al.* 2009). Within the Domain *S. austriacum* has been found in lawns in the herbetum, a few tens of metres away from cultivated plants.

• ***Solanum citrullifolium*** (Solanaceae), an annual native to southern North America, has leaves similar to those of *Citrullus lanatus* (watermelon), stems and fruits covered with long straight spines, and star-shaped purple flowers. It is naturalized in Portugal and Spain, and is reported as casual alien from Denmark and Hungary; no records exist from Belgium. Several seedlings have been found in different parts of the herbetum, up to more than 50 m away from cultivated plants.

• *Spiraea* sp. A seedling of an unidentified *Spiraea* (Rosaceae) has been found in sector 53, some 250 m away from the *Spiraea* collection in the Botanic Garden.

• *Sporobolus indicus* (Poaceae) has a worldwide distribution in tropical and warm-temperate areas. It is native to South Africa and is naturalized and invasive in several continents, hindering the regeneration of native vegetation, especially on moist soils (Weber 2003). Recently, it has also been observed in two locations in northern France (Bedouet 2009). Within the Botanic Garden it is cultivated in the herbetum; it has been found growing in another sector at a distance of about 200 m.

• ***Tetradium daniellii*** (syn.: *Euodia daniellii*; Rutaceae) is an ornamental tree from Korea and North China. It is naturalized in parts of the USA and has been recorded as casual from Hungary. Bee keepers plant it for its nectar producing flowers that open in late summer. Several seedlings have been found at a distance of 5 to 10 m from the parent trees.

• *Tetragonia tetragonioides* (Aizoaceae) is native to New Zealand, Australia, Japan, and parts of South America. It is cultivated as spinach, and is naturalized in parts of the USA. In the 19th century, escapes from cultivation have been recorded from several European countries, including Belgium. Within the Domain seedlings of escapes have been found in the herbetum, at a distance of up to 50 m.

• *Thuja* sp. (Cupressaceae). Two seedlings of *Thuja* were found in different locations in sector 58, where several different species of *Thuja* are cultivated, namely *T. occidentalis*, *T. standishii*, and various cultivars of *T. plicata*. The latter species has been recorded as a neophyte from Flanders in 2004 and 2005 (Verloove 2006).

• *Triticum* sp. (Poaceae). From 2008 to 2010 isolated wheat plants were recorded each year in varying sectors, usually more or less close to the herbetum and the medicinal garden. *Triticum* has also been recorded as a casual in the wider region around the Botanic Garden, but still we presume that the plants found within the Domain were collection escapes. Indeed, *Triticum aestivum* is cultivated in the medicinal garden, and *T. turgidum* subsp. *durum* is cultivated in the herbetum. Both have been recorded as neophytes from Belgium (Verloove 2006).

• *Ulex* sp. (Fabaceae). A seedling of *Ulex* has been found in sector 42, close to the nursery. Both *Ulex europaeus* (native to Belgium) and *U. parviflorus* subsp. *parviflorus* (not native) are cultivated in the fruticetum. The only *Ulex* recorded as neophyte in Belgium, is *U. minor*. In Flanders, *U. europaeus*, which is rather rare and declining, is mainly restricted to sandy soils (Van Landuyt *et al.* 2006). It is quite rare in the wide area of Meise. It is mentioned in the list of the world's one hundred most invasive

organisms (Lowe *et al.* 2000), and is widely naturalized in North and South America, in parts of Asia and Africa, and in New Zealand. On the other hand, *U. parviflorus*, which is native to the western Mediterranean, is not known as a neophyte.

• *Valerianella locusta* (Valerianaceae) is a rather common indigenous weed species of arable fields and roadsides. It is cultivated in the herbetum, and sows itself in plant beds of other species.

• *Verbascum nigrum* (Scrophulariaceae) is indigenous to Flanders, where it is rather common, mainly in the east. In the herbetum seeds are dispersed up to several tens of metres away from the cultivated plants.

• *Verbena bonariensis* (Verbenaceae), native to tropical South America, is cultivated as a garden plant. It self-seeds readily, so that is has become naturalized, or even invasive, in many parts of the world. Weber (2003) reports it as a neophyte in parts of Africa, Asia, Oceania and North America; it overgrows natural vegetation in South Africa and Australia. It has been reported as casual alien in several European countries, including Belgium, where it has been observed since the nineteenth century without ever showing signs of naturalization. In the Netherlands it is increasingly recorded as a garden escape (http://www.knnv.nl/amsterdam/stijfijzerhard.htm). Seedlings have been found in four sectors in several parts of the Botanic Garden; they grow at distances of between 500 and 1000 m from the nearest cultivated plants.

• Verbena canadensis (Verbenaceae) is native to eastern North America, where it inhabits open grasslands and rocky sites. It is cultivated for its profuse purple flowers, even when grown in dry sites. There are few records of it as neophyte; only in Portugal has it been reported as naturalized. Within the Domain a few seedlings have been found at a distance of several metres outside their plant bed in the herbetum.

• ***Vernonia fasciculata*** (Asteraceae) is a perennial plant that is native to parts of the USA, where it often grows in wetland habitats such as moist prairies and marshes. It grows to a height of 150 cm, has dense clusters of purple capitulae, and has achenes that are spread by the wind (http://www.illinoiswildflowers.info/prairie/plantx/sm_ironweedx.htm). We found no reports of invasive behaviour of this species, although it is mentioned as a weed in Idaho. It has been planted in the Botanic Garden along the orangery lake. In 2009, a cluster of flowering plants was found some five metres from the cultivated plants, in a wet spot of the lawn that had not been mown for some time. The next year these plants had disappeared, probably cut by the lawn mower.

• ***Viburnum plicatum*** (Caprifoliaceae), native to eastern Asia, is a deciduous shrub up to 3 m tall. It is naturalized in Australia, New Zealand and the USA. It's a popular ornamental plant for gardens and parks, with many cultivars. There are no records of it as a neophyte in Europe. In the Botanic Garden two self-sown plants were found at a distance of respectively 50 and 200 m from the nearest cultivated plants; one non-flowering plant grew in the undergrowth of a wooded area. The living collections contain 6 cultivars and 2 natural varieties of this species; they have all been planted between 1960 and 1985.

• ***Viburnum ×rhytidophylloides*** (Caprifoliaceae), a hybrid between *V. rhytidophyllum* and *V. lantana*, is a semi-evergreen shrub with broad leaf foliage. It is used as an ornamental plant, and has been reported as naturalized in the USA. It is also known as a persistent neophyte in the British Isles (Clement & Foster 1994). The plant is not mentioned in the catalogue of Belgian neophytes, but one of its parents (*V. rhytidophyllum*) is known as a casual adventive species since 1990 (Verloove 2006). Within the Domain several seedlings or young plants have been observed in two locations, both more than 500 m away from the nearest cultivated plants. Some of the cultivated plants belong to the cultivars 'Alleghany' and 'Holland'.

• *Vicia faba* (Fabaceae) is native to North Africa and parts of Asia, and is widely cultivated for human food and animal feed in fields and gardens. It has been reported as naturalized, as an agricultural weed or as a casual escape from Australia, New Zealand, the USA, and

several European countries. In Belgium it has been recorded since the 19th century. Within the Domain single plants have been found in two sectors, at a distance of 250 and 750 m respectively from the nearest cultivated plants. We presume that these have originated from collection escapes, since the species is only rarely found in the region around the Domain.

Discussion and conclusion

In total 156 species of garden escapes have been counted in the Domain of the National Botanic Garden of Belgium, this is about one quarter of all non-cultivated species recorded from the Domain during our survey. Both herbaceous and woody species occur as garden escapes. Although herbaceous plants are more numerous, they are not the most persistent species. The source of most herbaceous species is the herbetum, a collection of herbaceous plants arranged according to their family.

About one quarter of the garden escapes are species that are native to Flanders. Indeed, many indigenous species are cultivated in the collections, and they can be presumed to be adapted to the prevailing local climatological and other conditions. However, many of the native species cultivated in the Botanic Garden don't have a Belgian origin, but have been introduced from other European countries. Some of these plants, for example, may have originated from an area with a harsher climate, and therefore resist winter cold better than expected. This is the case for *Oenanthe pimpinelloides* that has always been a rare species in Belgium with only ephemeral populations, probably due to its cold sensitivity. However, plants from Bulgaria have been in cultivation in the Botanic Garden since 1978, and these have escaped into lawns (Ronse 2005).

Thirty eight species that have been recorded as garden escape from the Domain have not been reported before as neophyte in Belgium (Verloove 2006). This represents one third of all alien species that were found as escape from the collections! Most of these species, however, have been reported as neophyte in some part of the world. For no more than six species in our list have we been unable to find any indication about naturalized populations or more or less frequently recorded casuals outside their natural range. These species are *Amorpha californica*, *Betula raddeana*, *Cyclanthera brachystachya*, *Hieracium islandicum*, *Rubus xanthocarpus* and *Vernonia fasciculata*.

The distance over which the garden escapes have spread varies a lot, from a few metres distance from the source, to nearly one kilometre (which is the largest distance that can be measured within the Domain). The spread is largely dependent on how seeds or propagules are dispersed. Several of the species that have bridged more than 100 m are thought to be dispersed by zoochory, e.g. *Diospyros lotus* by birds (De Meyere 2005) or *Oenanthe pimpinelloides* by geese (Ronse 2005).

Whether escapes from the collections have also spread outside the Domain, is difficult to answer. Many of the garden escapes are also external neophytes: these alien species are present elsewhere in Flanders too, often including locations not very far away from Domain. In these cases it is impossible to know whether plants in the vicinity of the Botanic Garden have originated from within or without the Domain, certainly so without carrying out genetic studies. That is also the case for the nine species of garden escapes known as invasive neophytes in Belgium (marked in the last column of table 1), that are more or less well established in the region.

The persistence of the populations of most garden escapes is low: many plants only survive one or two years. This is certainly due to the fact that the open spaces of the Domain are regularly weeded and that most lawns are frequently mown. Furthermore, the Botanic Garden is permanently monitored in order to check species that might become invasive. Some species are removed from the collections when they turn out to be 'aggressive' invaders or when they are a reputed hazard to public health, like *Heracleum mantegazzianum* and *Ambrosia artemisiifolia*. The less managed areas are certainly the wooded areas that are left undisturbed for most of the time. In these areas the probability for some plants to remain

unnoticed is the highest. Since most unwanted plants are quickly removed, it is likely that many escaped species have remained unnoticed during this survey. This means that the above-mentioned list of garden escapes is certainly incomplete. Ideally there should be a more or less permanent monitoring of the vegetation in the Domain in order to detect spontaneously dispersing species and prevent (potential) invaders from escaping from the collections and into the vicinity of the Botanic Garden.

The number of plants of each species of garden escape has usually been recorded, and, on the whole, it is low. In only four cases more than 100 individuals were counted; these species are *Diospyros lotus* (De Meyere 2005), *Mentha pulegium* (Ronse, in prep.), *Pterocarya stenoptera*, and *Ranunculus parviflorus* (Ronse 2011d).

Based on our results, we conclude that although many species of garden escapes have been found in the Domain, there are probably many more species that escape, but most are quickly controlled by weeding or mowing. Most of the garden escapes spread only over a small distance, they survive no longer than a few years, and they do not persist in large numbers. Some species, however, combine a rather long distance dispersal, a high persistence and high numbers of plants, and these are the plants that should be closely monitored. This is also the case for species mentioned in the list of invasive aliens in Belgium (Verloove 2006). In certain cases plants should be removed from the living collections. Other species that should be watched closely are those that are known to behave as aggressive aliens in some parts of the world, especially in areas with a climate similar to the one in Western Europe. Here, 95 % of the garden escapes found in this study are species behaving as invasive neophytes somewhere. Not all escapes perform equally well, largely depending on the environment in which the propagules have landed.

Literature

Alanen A., Bongard T., Einarsson E., Hansen H., Hedlund L., Jansson K., Josefsson M., Philipp M., Sandlund O.T., Svart A.E., Svart H.E. & Weidema, I. (2004) – Introduced Species in the Nordic Countries (Denmark) under Nordic Council of Ministers (NMR), subgroup Natur-og Friluftslivsgruppen.

Armitage J. (2010) – The wild flora of Wisley. *The Plantsman* **9(4)**: 250-253.

Bakker P. & Boeve E. (1985) – Stinzenplanten. Zutphen & 's-Graveland, Terra & Vereniging tot Behoud van Natuurmonumenten in Nederland.

Bedouet F. (2009) – « Bienvenue chez les ch'tis » ou la liste des principales espèces en extension récente dans le Nord-Pas de Calais ou présentes depuis peu aux portes de la région. *Le jouet du vent* **21**: 5.

Botond M. & Zoltán B.D. (eds.) (2004) – Biological Invasions in Hungary. Invasive Plants. Természet BUVAR Alapítvány Kiadó.

Branquart E. (ed.) (2011) – Alert, black and watch lists of invasive species in Belgium. Harmonia Version 1-2. Belgian Forum on Invasive Species. [http//ias.biodiversity.be, as accessed on 28.01.2011]

Briggs M. (1986) – Asarina procumbens Miller. *B.S.B.I. News* **43**:20-21.

Buffin M.W. (2005) – Winter-flowering shrubs. Portland (Oregon), Timber Press.

Clement E.J. & Foster M.C. (1994) – Alien plants of the British isles. A provisional catalogue of vascular plants (excluding grasses). London, BSBI.

David J. (2009) – A new forest fringes forb association: Deschampsia caespitosae-Inuletum helenii in SW-Hungary. *Natura Somogyiensis* 15: 7-14.

De Meyere D. (2005) – Dendrologische notities: Nationale Plantentuin, Meise. *Jaarboek van de Belgische Dendrologische Vereniging* **2005**: 100-106.

Denters T. (2004) – Stadsplanten: veldgids voor de stad. 's-Graveland, Fontaine Uitgevers.

Dickoré W.B. & Kasperek G. (2010) – Species of Cotoneaster (Rosaceae, Maloideae) indigenous to, naturalising or commonly cultivated in Central Europe. *Willdenowia* 40: 13-45.

Firsov G.A. (1998) – Betula raddeana. *In* IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. [www.iucnredlist.org, as accessed on 25 August 2011.]

Groves R.H., Boden R. & Lonsdale W.M. (2005) – Jumping the garden fence. Invasive plants in Australia and their environmental and agricultural impacts. CSIRO report prepared for WWF-Australia. Sydney, WWF Australia.

Güemes J. (2009) – Asarina. *In* Castroviejo S. (ed.), Flora Ibérica, vol. 23: 207-209. Madrid, Real Jardín Botánico.

Hoste I. & Geerinck D. (2011) – The vegetation of the enclosed courtyard at the herbarium building. *Scripta Bot. Belg.* **47**: 145-153.

Hulme P.E. (2011) – Addressing the threat to biodiversity from botanic gardens. *Trends Ecol. Evol.* **26 (4)**: 168-174.

Jacquemyn H., Van Looy K., Breyne P. & Honnay O. (2009) – Langeafstandsverbreiding van de Maasraket

langs de Grensmaas. Exoot lift mee met rivierdynamiek. *Natuur.focus* **8 (3)**: 84-89.

Kent, D.H. (1956) – Senecio squalidus L. in the British Isles. 1. Early records (to 1877). *Proc. Bot. Soc. Br. Isl.* **2**: 115-118.

Korneck D. & Krause A. (1990) – Lysichiton americanus Hulten & St John (Araceae), ein Neubürger im Hochtaunus. *Hess. Florist. Briefe* **39**: 53-56.

Lambinon J., Delvosalle L. & Duvigneaud J. (2004) – Nouvelle flore de la Belgique, du Grand-Duché de Luxembourg, du Nord de la France et des Régions voisines. 5e édition. Meise, Jardin botanique national de Belgique.

Lowe S., Browne M., Boudjelas S. & De Poorter M. (2000) – 100 of the world's worst invasive alien species. A selection from the Global Invasive Species Database. Invasive Species Speciality Group, Auckland, New Zealand. [http://www.gisp.org/publications/reports/100worst.pdf]

Mitchell R.S. (ed.) (1986) – A checklist of New York State plants. Contributions of a Flora of New York State, Checklist III. *New York State Bulletin* **458**.

Mosyakin S.L. & Yavorska O.G. (2002) – The Nonnative Flora of the Kiev Urban Area, Ukraine: A Checklist and Brief Analysis. Urban habitats 1 (1). Kiev, M.G. Kholodny Institute of Botany, National Academy of Sciences of Ukraine.

Preston, C.D., Pearman, D.A. and Dines, T.D. (2002) – New Atlas of the British & Irish Flora. Oxford, Oxford Univ. Press.

Rhoads A.F. & Klein W.M. Jr. (1993) – The vascular flora of Pennsylvania. Annotated checklist and atlas. *Memoirs of the American Philosophical Society* **207**. Morris Arboretum, University of Pennsylvania, USA.

Ronse A. (2005) – Oenanthe pimpinelloides: bedreigde soort of invasieve neofyt? *Dumortiera* **84**: 11-14.

Ronse A. (2011a) – The wild flora of the Botanic Garden: an introduction. *Scripta Bot. Belg.* **47**: 27-58.

Ronse A. (2011b) – Stinsen plants and other deliberate introductions in the (semi-) natural zones of the Botanic Garden. *Scripta Bot. Belg.* **47**: 67-75.

Ronse A. (2011c) – External neophytes. *Scripta Bot. Belg.* **47**: 77-88.

Ronse A. (2011d) – Expansion of the alien Ranunculus parviflorus in the Botanic Garden. *Scripta Bot. Belg.* **47**: 127-129.

Ronse A. & Groom Q. (2011) – Fumaria parviflora in Belgium, extinct or not? *Scripta Bot. Belg.* **47**: 125-126.

Saintenoy-Simon J. & Duvigneaud J. (2002) – Le domaine royal de Laeken. *Adoxa* **34**: 27-31.

Tutin T.G., Heywood V.H., Burges N.A., Moore D.M., Valentine D.H., Walters S.M. & Webb D.A. (1968) – Flora Europaea, vol. 2: Rosaceae to Umbelliferae. Cambridge, Cambridge Univ. Press.

Van Landuyt W., Hoste I., Vanhecke L., Van den Bremt P., Vercruysse W. & De Beer D. (2006) – Atlas van de flora van Vlaanderen en het Brussels Gewest. Brussel & Meise, INBO, Nationale Plantentuin van België & Flo.Wer.

Verloove F. (2006) – Catalogue of neophytes in Belgium (1800-2005). *Scripta Botanica Belgica* **39**. Meise, National Botanic Garden of Belgium.

Verloove F. (2011) – Fraxinus pennsylvanica, Pterocarya fraxinifolia en andere opmerkelijke uitheemse rivierbegeleiders in België en Noordwest-Frankrijk. *Dumortiera* **99**: 1-10.

Weber E. (2003) – Invasive plant species of the world. A reference guide to environmental weeds. Oxford, CABI Publishing.

Wilson R. (2003) – Lysichiton americanus American skunk-cabbage. *In* Preston C.D., Pearman D.A. & Dines T.D., New atlas of the Britisch & Irish flora: 684. Oxford, Oxford Univ. Press.

Yinxin L., Zaoyhang C. & Yakovlev G.P. (2010) – Caragana Fabricius. *In* Flora of China 10: 528-545. St-Louis, Missouri Botanical Garden Press.

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Wood lawn neophytes: historical park relics

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Scripta Bot. Belg. **47**: I. Hoste (ed.), The spontaneous flora of the National Botanic Garden of Belgium (Domein van Bouchout, Meise)

Résumé. – Néophytes des gazons forestiers, vestiges d'anciens parcs. Le terme néophyte des gazons forestiers est décrit et expliqué en reprenant brièvement la littérature à ce sujet. Ces espèces non indigènes ont été introduites involontairement dans le Domaine à Meise au dix-neuvième siècle à l'occasion de l'aménagement de gazons forestiers. Neuf espèces ont été répertoriées, toutes des graminées ou des espèces y ressemblant, qui sont rares à extrêmement rares en Flandre. Les espèces sont originaires d'Allemagne. Entre 1990 et 2000-2010 il y a eu une forte augmentation du nombre de plantes de *Dactylis polygama* dans le Domaine, et en moindre mesure de *Carex divulsa* et *C. muricata*. Ce sont trois espèces indicatrices d'un taux moyen à élevé d'azote dans le sol, tandis que les autres néophytes des gazons forestiers à Meise croissent à des taux inférieurs d'azote.

Samenvatting. – Bosgazon-neofyten als historische parkrelicten. Het begrip bosgazon-neofyt wordt beschreven en toegelicht aan de hand van de bestaande literatuur over dit onderwerp. Deze niet-inheemse soorten werden ook in het Domein te Meise ongewild geïntroduceerd bij de aanleg van bosgazons rond beide kastelen in de negentiende eeuw. Er werden negen soorten aangetroffen, allemaal grassen of grasachtige planten (veldbiezen en zegges) die zeldzaam tot uiterst zeldzaam zijn in Vlaanderen. Alle soorten zijn afkomstig uit Duitsland. Tussen 1990 en 2000-2010 is er een sterke toename geweest van *Dactylis polygama*, en in mindere mate van *Carex divulsa* en *C. muricata*. Dit zijn de enige soorten die duiden op een middelmatig tot hoog stikstofgehalte van de bodem; alle andere waargenomen bosgazon-neofyten zijn indicatoren voor een laag stikstofgehalte.

Introduction

The Domain of the National Botanic Garden of Belgium in Meise was created when two former castle grounds (Bouchout and Meise) were joined into a single park (Ronse & Vidts 2011). The management of these ancient estates, before the transfer of the Botanic Garden from Brussels to the Domain, was clearly influenced by their actual landscape and species composition. Today, the Botanic Garden contains a group of peculiar species that were unintentionally introduced in the 19th century, when parts of the castle estates were laid out into English style parks. We have named this group of species 'wood lawn neophytes' in our introductory overview of the spontaneous flora of the Botanic Garden (Ronse 2011a, this volume, p. 33: category 5). These plants are not indigenous to the Domain and environs. They have either been introduced to open spaces or to the edges of wooded areas when so-called wood lawns were created, and have survived into the 21st century. Many of these species are (very) rare in Flanders and have been recorded only from a few similar old parks.

In this contribution we first give an overview of the historical knowledge on this category of plants and their distribution in West-

ern Europe. Then we discuss their occurrence in the Botanic Garden today as well as two decades ago, when they were first noticed and identified.

Wood lawn neophytes

The first report on this peculiar group of neophytes dates from 1882, when H. Nilsson described the presence of *Luzula luzuloides* and *Poa chaixii* in a park in Skåne (Sweden). None of these species is indigenous to this region. They were hypothesized to have been unwittingly imported to the park as contaminants of German grass seed that had been used for the creation of a 'wood lawn'. Subsequently other Scandinavian authors (a.o. Wiinstedt 1927, Hylander 1943, Nordhagen 1954) reported findings of these species in several parks in Denmark, Norway and Sweden, together with about twenty other species that were not considered indigenous. Hylander described these plants as 'Grassameneinkömmlinge', a name that indicates they had been imported with grass seed mixtures. Since there is no corresponding word in English for these neophytes, we have coined an adequate English name. And as several more neophytes have recently been introduced with grass seeds, we have not literally translated the German word, but chosen the name 'wood lawn neophytes'.

Outside Scandinavia, similar records existed from other regions, for instance Great Britain, where *Poa chaixii* has been reported from several old parks and country estates, often together with *Festuca heterophylla*. It was first observed in the wild in 1852 (Preston *et al.* 2002). In the Netherlands *Luzula luzuloides*, *L. sylvatica*, *Poa chaixii*, *Festuca heterophylla* and several *Hieracium* species have been recorded from parks in country estates, usually situated in the western part of the country, where they are not indigenous. These species have also probably been imported with grass seed when the parks were laid out (Londo 1959, Kruseman & Westhoff 1959, Reichgelt 1960). According to Heukels (1980) *Festuca heterophylla* has been recorded from four grid squares after 1950. In the north-eastern part of Germany 'wood lawn neophytes' were found in the historical parks of Potsdam near Berlin. These parks, designed by Peter Joseph Lenné, are on the UNESCO World Heritage List. The shaded 'forest meadows' highly contribute to the urban biodiversity as they contain species that are not found elsewhere, according to Zerbe *et al.* (2004).

The first use of grass seed for laying out 'forest meadows' in Scandinavia agrees with the introduction of English landscape gardening around 1780 (Hylander 1943; Nordhagen 1954); in Denmark the first examples are even a little older, dating from around 1760 (Jessen & Lind 1922). The design of the English landscape gardens was highly influenced by the book *Theorie der Gartenkunst* (Hirschfeld 1779-1785), which advocated naturally looking vast lawns and grasslands with isolated groups of trees. Their laying out required large amounts of seed of grasses adapted to shaded habitats. For this purpose, *Poa nemoralis*, *Festuca rubra* and *Deschampsia flexuosa* were usually used. Seed was imported from two main regions (Hylander 1943). The first was Central and South Germany. The grass seed was contaminated with seeds of grasses, sedges, rushes, and other flowering plants, namely *Poa chaixii*, *Luzula luzuloides*, *Dactylis polygama*, *Festuca heterophylla*, *Luzula sylvatica*, *Ajuga reptans*, *Milium effusum*, *Festuca gigantea*, *Festuca rubra* var. *commutata*, *Festuca ovina* subsp. *capillata* (= *F. filiformis* Pourr. in Lambinon *et al.* 2004), *Festuca trachyphylla* (= *F. brevipila* R. Tracey in Lambinon *et al.* 2004), *Carex divulsa* subsp. *leersii*, and several *Hieracium* species. A second important area of origin was south-eastern France (and possibly also the westernmost part of Switzerland); contaminants from this region were *Bromus erectus*, *Arrhenatherum elatius*, *Trisetum flavescens*, *Onobrychis viciifolia*, *Sanguisorba minor*, and *Crepis biennis*.

The Scandinavian grass seed mixtures were purchased mainly from Central Europe (companies near Hamburg) and possibly also from Dutch companies. The origin of the 'wood lawn neophytes' found in the Netherlands has been indicated as France or Italy by Heukels

(1980), but without justification or reference. In four castle estates in the western part of Germany (Nieder-Rhein) neophytes of both French and German origin have been recorded (Nath 1990).

Wood lawn neophytes in Meise

In the Domain of the National Botanic Garden at Meise several different 'wood lawn neophytes' have been found, both in the former estate of the Bouchout castle as in that of the former Meise castle. Parts of these estates were transformed into an English style landscape garden at the beginning of the 19th century. The park of the Meise castle was designed by François Verly, who probably also designed the gardens of the Bouchout castle (Ronse & Vidts 2011).

For this contribution, the data of the floristic mapping of the Domain from 2002 to 2010 have been complemented with data from around 1990 by the second author. This allows us to establish a trend for the occurrence of these species. It should, however, be borne in mind that the recording effort was higher during the recent survey. This means that the comparison of the frequencies in both periods is likely to result in an overestimation; therefore, if no change is apparent from the data, it could actually represent a slight decrease.

Luzula forsteri

Luzula forsteri is native to South and Southwest Europe, from Spain to the southern part of Great Britain. In Flanders it is only known from the Botanic Garden, where it is not considered indigenous (A. Ronse *in* Van Landuyt *et al.* 2006). In Wallonia only one locality is known, in Angre (IFBL H3.11/12) (Saintenoy-Simon *et al.* 2006). More to the south, in France, there are some isolated localities in the Boulonnais and Lorraine regions and in the Rhine valley, while it becomes more common south of the Somme (Vignon 1982).

In the Botanic Garden a population of several tens of plants was discovered in sector 29 in 1989 (see fig. 1 for the location of the sectors mentioned in this contribution), growing

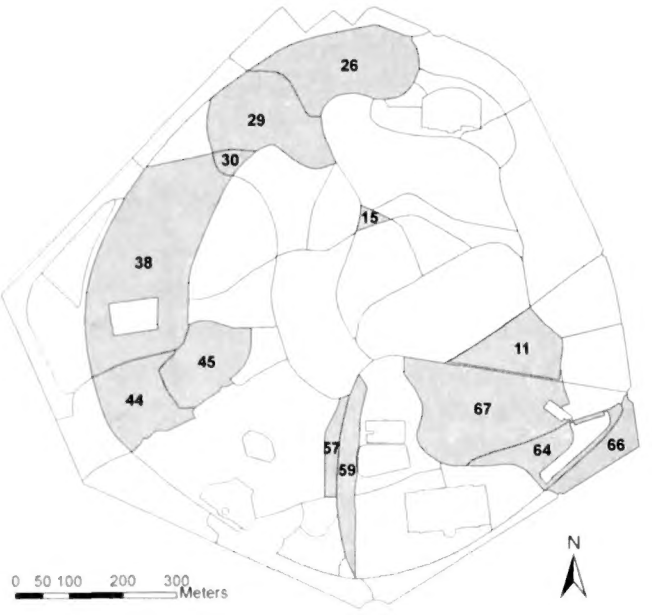

Figure 1. Location of the sectors mentioned in the text.

in an area of a few hundreds of square metres (herbarium M.Leten 1710, BR). A systematic search yielded three other populations in sectors 30 and 38, one of them rather large. All localities were situated in the former castle estate of Meise, in the northern part of the Domain. In three localities *L. forsteri* grew under large trees at the edge of a lawn, where the fallen leaves were removed each year. The fourth locality was situated in a regularly mown lawn, but also close to trees. All populations grew on heavy and locally rather dry loamy soils.

Vegetation relevés were made at the four localities (table 1). In the tree layer *Fagus sylvatica*, *Tilia* spec. and *Acer platanoides* were dominant. In the herbaceous layer *Poa trivialis* and seedlings of *Acer pseudoplatanus* were found in all quadrants, and in three of four quadrants *Agrostis capillaris*, *Anemone nemorosa*, *Dactylis polygama* (also a wood lawn neophyte, see further), *Ranunculus ficaria* and seedlings of *Sorbus aucuparia* were present. The remaining species are typical of deciduous forests on loamy soils, although relevé 4 also yielded some grassland species. Almost no nitrophilous species were recorded, which concords with the low Ellenberg indicator value for nitrogen (N=2) of *Luzula forsteri* (Ellenberg *et al.* 1992). In one quadrant, the rather ac-

Table 1. Relevés of the vegetation of locations with *Luzula forsteri* in Meise. Relevés according to Londo (1976) for the herbaceous layer and according to Tansley (1939) for the tree layer. The names of species present in 3 or 4 relevés are in bold. "(S)" after a name indicates the presence of seedlings.

	1	2	3	4
Date	03.04.1991	03.04.1991	03.04.1991	03.04.1991
Surface (m²)	2 x 2	2 x 2	3 x 1.5	2 x 2
Herbaceous layer (%)	4	40	75	60
Moss layer (%)	99	30	90	95
Litter (%)	10	50	25	3
Slope (%)	0	10	10	0
Acer platanoides	.	.	CD	.
Fagus sylvatica	D	CD	CD	.
Tilia spec.	.	CD	CD	D
Luzula forsteri	p.2	1	p.1	p.4
Acer pseudoplatanus (S)	p.1	p.1	a.1	p.1
Agrostis capillaris	p.2	1	.	p.2
Allium ursinum	.	.	.	a.2
Anemone nemorosa	.	2	4	3
Anthriscus sylvestris	.	.	.	p.1
Cardamine pratensis	.	.	r.1	p.1
Carex remota	.	.	r.1	.
Carex sylvatica	.	.	p.4	1
Carpinus betulus (S)	r.1	.	.	.
Cerastium fontanum	.	.	.	p.1
Dactylis polygama	.	1	2	2
Deschampsia cespitosa	.	a.2	1-	.
Fagus sylvatica (S)	.	r.1	.	.
Fragaria vesca	r.1	.	.	.
Geranium robertianum	.	.	r.1	.
Lysimachia nummularia	.	.	.	p.1
Oxalis acetosella	.	.	m.2	.
Poa nemoralis	r.1	.	.	.
Poa pratensis	.	.	.	r.1
Poa trivialis	p.1	r.1	r.1	1
Polygonatum multiflorum	.	r.1	r.1	.
Primula elatior	.	.	r.1	r.1
Prunella vulgaris	.	.	.	a.4
Ranunculus acris	.	.	.	r.1
Ranunculus ficaria	r.1	a.2	a.2	.
Silene dioica	.	.	r.1	.
Sorbus aucuparia (S)	r.1	r.1	.	r.1
Taraxacum	.	.	p.2	1
Urtica dioica	.	.	r.1	.
Viola reichenbachiana	.	.	1+	2
Atrichum undulatum	.	.	4	.
Brachythecium rutabulum	.	.	.1	.2
Kindbergia praelonga	.	.	1+	1-
Mnium hornum	10	3	4	.
Plagiomnium cf. affine	.	.	1	9

idophilic *Oxalis acetosella* was also found; the Ellenberg indicator value for acidity of the species points to rather neutral soils, however. In three of four relevés there was a nearly closed moss layer, with *Mnium hornum* as main species. Noteworthy species in the close vicinity of relevé 1 were *Campanula rapunculoides* (a rare and ambiguously indigenous species that has not been observed since 2000) and a non-flowering *Narcissus*.

During the recent mapping of the Domain, from 2002 to 2010, two of the former localities of *Luzula forsteri* was retrieved (sector 29 and 38). The survey also yielded three new localities, of which two (in sectors 57 and 59) were situated within the former castle estate of Bouchout. All plants grow at the edge of woodland.

Dactylis polygama

The natural range of *Dactylis polygama* lies in Central Europe, from the Alps to southern Scandinavia; its westernmost boundary lies east of Belgium. In Wallonia it has been recorded from a few localities (J. Duvigneaud: 1985, BR; herb. *A. Lawalrée* 23942, Annevoie), very likely as ephemeral casuals. In Flanders it has only been recorded from Meise (A. Ronse, *in* Van Landuyt *et al.* 2006). Lambinon *et al.* (2004) mentions *D. polygama* as having been sown in parks and woods as forage plant for game species.

The earliest known record from the Botanic Garden is a herbarium collection from 1982 (*A. Lawalrée* 23927, BR). In 1990 the second author found four rather large populations in sectors 29, 30, 66 and 67; at two of these stations *Luzula forsteri* was also present. Between 2002 and 2010 *D. polygama* was found in 22 sectors, including all four previous sectors (herb. *A. Ronse* 1705, 1753). It grows and is rather common in most forest edges in the Domain. It appears to have experienced a strong increase during the last twenty years. Its Ellenberg indicator value for nitrogen is moderately high (N=5).

Poa chaixii

Poa chaixii is among the most typical and most frequently mentioned woodland neophytes of German origin. It is native to the mountainous parts of Central Europe, and is furthermore found in northern Spain, central and eastern France, and the southern part of Belgium. In Flanders it is considered indigenous only in the extreme east (Voeren), with moreover some reports of adventitious populations in a few parks in the area around Brussels (P. Van den Bremt, *in* Van Landuyt *et al.* 2006). These localities are Overijse (Mommerency 1975), Groenendaal (Delvosalle: 1956, IFBL archives), and La Hulpe (Fabri & Saintenoy-Simon 1984).

Poa chaixii was first recorded from the Domain by the second author in 1990, when a few plants were found growing along the castle lane (sector 67). During the recent survey from 2002 to 2010, it was not refound there. A few plants, however, were found at the other side of the lane, as well as in another sector (15) (herb. *A. Ronse* 1708, BR). According to Ellenberg (1992) this species grows in rather acidic soils (R=3) and in not very nitrogen-rich circumstances (N=4).

Carex divulsa and *Carex muricata*

Both sedges are treated together here while they are very similar and were formerly treated as a single taxon. *Carex divulsa* has its main distribution area in Southwest, Central and South Europe, where it grows in forest edges on dry, basic and rather nutrient-rich soils. It is indigenous to Belgium, with most localities situated in the southern part of the country. It is very rare in Flanders, usually occurring as an adventitious plant, except in the east (L. Allemeersch, *in* Van Landuyt *et al.* 2006). Lambinon *et al.* (2004) distinguishes two subspecies, subsp. *leersii* and subsp. *divulsa*.

Carex muricata, a plant typical of forest edges, has a Euro-Siberian distribution. In Belgium it mainly occurs in Wallonia, being very rare in Flanders (L. Allemeersch, *in* Van Landuyt *et al.* 2006). Only subsp. *lamprocarpa* has been recorded from Belgium (Lambinon *et al.* 2004).

In 1990 the second author found three localities of *Carex divulsa* or *C. muricata* in the Botanic Garden (sectors 44, 64 and 67). In 1996 he also collected herbarium specimens that he identified as *Carex divulsa* subsp. *leersii* and *Carex muricata* subsp. *lamprocarpa*. During the more recent flora survey five localities of *C. divulsa* were found (sectors 11, 26, 38, 44 and 67; herb. *A. Ronse* 1299, 1760) and one locality with numerous plants of *C. muricata* (sector 67; herb. *A. Ronse* 1752). Both species are rather nitrophilous (N=6) according to Ellenberg *et al.* (1992).

Since *Carex divulsa* subsp. *leersii* has been mentioned as a wood lawn neophyte from Germany by Hylander (1943), and as most of the localities in the Botanic Garden contain other wood lawn neophytes, it seem logical to describe it as a wood lawn neophyte. The same probably holds true for *C. muricata*, even if this species was not mentioned by Hylander (1943) as a wood lawn neophyte, while in the 1940s the distinction between the two species was not yet made.

Luzula sylvatica

Luzula sylvatica has a mainly western European range that stretches northward up to parts of Scandinavia. It is indigenous to Belgium, where it mainly occurs in the south. In Flanders it is rare, with indigenous populations restricted to three regions, including the southern part of the province of Vlaams-Brabant. Outside these regions it has been recorded as a casual, sometimes originating from grass seed mixtures used in parks (P. Van den Bremt, *in* Van Landuyt *et al.* 2006). *Luzula sylvatica* is an 'ancient forest species' (Honnay *et al.* 1998), but it has also been described as a wood lawn neophyte of German origin (Hylander 1943). It has a rather low Ellenberg indicator value for nitrogen (N 4).

In the Botanic Garden *L. sylvatica* has only one locality, in sector 26, where it grows under large trees at the edge of a shaded lawn, together with *Ranunculus auricomus*, another ancient forest species. Two other wood lawn neophytes have also been recorded from the same sector, although on different spots: *Carex divulsa* and *Festuca* spec. Since Meise lies outside the zones where *L. sylvatica* is considered indigenous to Flanders and shares the same sector and habitat with wood lawn neophytes in the Domain, it has been considered here as wood lawn neophyte. It might, however, also be truly indigenous.

Festuca heterophylla and *Festuca* spec.

Two or maybe three *Festuca* species recorded from the Botanic Garden could maybe be called wood lawn neophytes. One belongs to the group of *Festuca rubra*, the two others to the group of *F. ovina*. In order to identify them, anatomical leaf sections were made, and the floras of Lambinon *et al.* (2004) and Haeupler & Muer (2000) were used.

The first species has been identified as *Festuca heterophylla*, a taxon that belongs to the group of *Festuca rubra*, and is native to South and Central Europe and Southwest Asia. In Belgium it is indigenous only to the southern part of Wallonia; elsewhere it has once been recorded as a casual from an old park in Wallonia, where some stinsen plants and naturalized woody species are present as well (Duvigneaud *et al.* 1993).

In the Domain *Festuca heterophylla* has been observed in one place in sector 45, in grassy vegetation under a group of birch trees, together with *Luzula forsteri*. It has been reported as wood lawn neophyte of German origin by Hylander (1943), just as *L. forsteri*. In Great Britain too this *Festuca* occurs as wood lawn neophyte. It has been introduced there since 1812 and has been used as ornamental grass, for soil cover or even as forage plant. During the Victorian era it was a component of grass seed mixtures used in parks and gardens. The first reports of populations in the wild are from 1874 (Preston *et al.* 2002).

Another *Festuca* species found in the Domain is *Festuca brevipila*. This species has been listed as a 'Grassameneinkömmling' by Hylander (1943) as *F. trachyphylla* (Hack.) Krajina, a synonym of this species. However, it is frequently sown in Belgium in road and railway sides and lawns, and it is considered indigenous in the Flemish plant atlas, so we don't consider it as a wood lawn neophyte here.

Yet another, until now undetermined species of the *Festuca ovina* group has been found in one location in the Domain. This too may be a wood lawn neophyte. It is clearly not a native species.

Luzula luzuloides

This species has its main range in Central Europe. It is indigenous to parts of Wallonia and to the easternmost part of Flanders (Voeren). Outside its natural range in Flanders it has been recorded as an alien from the Sonian Forest and

Meerdaal, both in the province of Vlaams-Brabant; at some other localities it has been found as adventitious plant. In Flanders it is very rare and declining (P. Van den Bremt, *in* Van Landuyt *et al.* 2006). It has a rather low Ellenberg nitrogen indicator value (N=4) and is limited to rather acidic soils (R=3).

In the Botanic Garden a small population has been observed along the castle lane in 1991, but it has not been seen again since 2000. We assume that it had been brought in with grass seed during the 19th century, as it is mentioned as a wood lawn neophyte from Germany by Hylander (1943), and has been found in the Domain growing in the company of other wood lawn neophytes.

Discussion and conclusion

In the Botanic Garden nine wood lawn neophytes have been found, which is only 1.5 % of all species observed in the Domain. They are all grasses or similarly looking plants, such as sedges and woodrushes. In Flanders, their status varies from rare to extremely rare, and one species has not been reported before, namely *Festuca heterophylla*. All species that have been found in more than one sector have been found in the areas of both former castle estates.

Of these nine species, only three have shown a marked increase in the period from 1990 to 2000-2010, namely *Carex divulsa* and *C. muricata*, for which the number of localities has doubled, and *Dactylis polygama*, which has experienced a more than fivefold increase. Three species recorded from a single locality in 2000-2010 had not been found before, including two taxa of *Festuca* that are not easy to identify. As explained in the introduction, the increased number of records probably overrates the real trends because of increased recording intensities. However, for *Dactylis polygama* it can safely be assumed that there has been a real and marked increase of its occurrence in the Domain. The two sedges may also have really increased.

The three (strongly) increasing species possess a moderate to somewhat high nitrogen indicator value (N=5-6), whereas the other species of wood lawn neophytes in the Domain have a low nitrogen indicator value (N=2-4). This agrees with the general conclusion that in Flanders a decline of vascular plants has mainly taken place for species with low nitrogen indicator values; these are the species that have suffered most from general eutrophication (Hoste *et al.*, *in* Van Landuyt *et al.* 2006). As the trend for most wood lawn neophytes is negative, we deduce that in general they should not be considered as invasive neophytes. Only *Dactylis polygama* has known a striking increase within the Botanic Garden over the last 20 years, and should therefore be watched with care. For the time being, however, it does not appear to threaten indigenous vegetation.

From the literature we know that the grass seed mixtures of German origin mainly contained seeds of *Poa nemoralis* and *Deschampsia flexuosa*. Both these species are indigenous to Flanders and occur within the Domain, although the latter only on a few spots. It is probable that they have both been sown when the English style park was laid out in the former castle estates. Today's populations in the Domain may in fact be a genetic mixture of a native population and plants of German origin, or they may even be purely alien. Similar questions could be raised about the populations of some other indigenous species in the Domain, such as *Milium effusum*, *Carex sylvatica*, *Brachypodium sylvaticum*, and *Festuca gigantea*. Pending genetic analysis, little can be said about this. It may also be judicious to mention here that *Hieracium lachenalii* has been found in several locations in the Domain, since several (micro)species of *Hieracium* have been reported as wood lawn neophytes, however the species is considered indigenous in Meise (Ronse 2011b). The unresolved origin of the wood lawn neophytes illustrates their problematic status and nature conservation value. It is indisputable that these species represent at least a real cultural heritage value. But how should these populations be treated in a nature conservation context? The criteria of the Flemish Red List (Van Landuyt *et al.* 2006), which is the main reference for plant conservation in Flanders, result in a rather ambiguous

situation. At least a clearer distinction between the concepts of local origin and of administrative reference area is needed. It seems, for instance, somewhat odd that two wood lawn species (*Poa chaixii* and *Luzula forsteri*), both with their nearest native populations some 60 to 100 km away from the Botanic Garden, are treated completely differently. The first species is considered 'rare', with a single indigenous station situated within the administrative borders of the Flemish Region (in Voeren, at 100 km); the second one is not in the Red List due to 'criteria not applicable', while the population in Angre is situated in Wallonia, at a distance of 75 km. Similarly, neither *Dactylis polygama* nor *Festuca heterophylla* are mentioned in the Red List, as they have no indigenous populations within Flemish borders. At the same time all the populations of *Carex divulsa*, *Luzula luzuloides*, etc. are accepted as 'indigenous' in the figures that served as a basis for evaluation, although only (a small) part of these populations are supposedly native.

Conservation policy is often based upon artificial concepts of the nativeness of species. These concepts are defined by artificial temporal and spatial boundaries. Using such a strict definition for species worthy of conservation will fail to protect rare non-invasive alien species, such as wood lawn neophytes. It can be argued that the heritage value of these wood lawn neophytes makes them valuable in their own right. Even though they are not native, they are part of a rare habitat.

References

Duvigneaud J., Fasseaux W. & Saintenoy-Simon J. (1993) Festuca heterophylla au Mont Picard (Huy, province de Liege, Belgique). *Natura mosana* **46(4)**: 139-143.

Ellenberg H., Weber H.E., Düll R., Wirth V., Werner W. & Paulissen D. (1992) Zeigerwerte von Pflanzen in Mitteleuropa. *Scripta Geobotanica* **18**: 1-258.

Fabri R. & Saintenoy-Simon J. (1984) Compléments a l'atlas de la flore belge et luxembourgeoise (ed. 2): Synthese 1983. *Dumortiera* **28**: 15-36.

Hacupier H. & Muer T. (2000) Bildatlas der Farn- und Blütenpflanzen Deutschlands. Stuttgart: Eugen Ulmer Verlag.

Heukels P. (1980) Een zwenkgras (Festuca heterophylla). *In*: Meijerink J. *et al.* (Eds.) Atlas of the Netherlands flora I: extinct and very rare species: 111. The Hague Boston London: Dr. W. Junk bv Publishers.

Hirschfeld C.C.L. (1779-1785) Theorie der Gartenkunst. Vol. I-V. Leipzig: Weidmanns Erben und Reich.

Honnay O., Degroote B. & Hermy M. (1998) Ancient forest plant species in Western Belgium: a species list and possible ecological mechanisms. *Belg. Journ. Bot.* **130 (2)**: 139-154.

Hylander N. (1943) Die Grassameneinkömmlinge Schwedischer Parke. Mit besonderer Berücksichtigung der Hieracia Silvaticiformia. *Symbolae Botanicae Upsalienses* **7 (1)**: 1-432.

Jessen K. & Lind J. (1922-23) Det danske Markukrudts Historie. Kfl. Sanske Vid. Selsk. Skr. 8. Raekke. Naturv. Og Mathem. Afd 8. Kobenhavn.

Kruseman G. & Westhoff V. (1959) Poa chaixii, Luzula luzuloides en Luzula maxima bij Wassenaar. *Gorr. bl. Rijksherb.* **13**: 138-140.

Lambinon J., Delvosalle L. & Duvigneaud J. (2004) Nouvelle flore de la Belgique, du Grand-Duche de Luxembourg, du Nord de la France et des Regions voisines. 5e edition. Meise, Jardin botanique national de Belgique.

Londo G. (1959) Festuca heterophylla Lamk. en andere zeldzame planten bij Haarlem. *Gorr. bl. Rijksherb.* **14**: 151-153.

Londo G. (1976) The decimal scale for releves of permanent quadrats. *Vegetatio* **33**: 64-64.

Mommerency P. (1975) Poa chaixii in Brabant. *Dumortiera* **3**: 30.

Nath M. (1990) Historische Pflanzenverwendung in Landschaftsgarten. Worms: Wernersche Verlagsgesellschaft.

Nilsson N.H. (1882) Luzula albida i artratt i var flora. Botaniska Notiser. Lund Botanical Society: Sweden.

Nordhagen R. (1954) Om gjennombruddet av den engelske landskapsstil i nordisk havekunst og dens betydning for Nordens flora. (On the introduction of the English landscape style in Scandinavian ornamental gardening and its bearing on the flora of Scandinavia). *Blyttia* **12**: 97-101.

Preston C.D., Pearman D.A. & Dines T.D. (2002) New atlas of the British & Irish flora. Oxford: Oxford Univ. Press.

Reichgelt Th.J. (1980) Over enige niet graszaden in parken en fruitplaatsen ingevoerde planten. *Gorr. bl. Rijksherb.* **15**: 161-163.

Ronse A. (2011a) The wild flora of the Botanic Garden: an introduction. *Scripta Bot. Belg.* **47**: 27-58.

Ronse A. (2011b) The truly indigenous flora. *Scripta Bot. Belg.* **47**: 59-66.

Ronse A. & Vidts S. (2011) A short history of the land use and vegetation of the Botanic Garden. *Scripta Bot. Belg.* **47**: 19-26.

Saintenoy-Simon J., Barbier Y., Delescaille L.-M., Dufrêne M., Gathoye J.-L. & Verte P. (2006) Premiere liste des especes rares, menacées et protegées de la Region

Wallonne (Pteridophytes et Spermatophytes). Version 1. Direction Generale des Ressources Naturelles et de l'Environnement, Ministère de la Région Wallonne.

Tansley A.G. (1939) — The British Isles and their vegetation. Cambridge, Cambridge Univ. Press.

Van Landuyt W., Hoste I., Vanhecke L., Van den Bremt P., Vercruysse W. & De Beer D. (2006) — Atlas van de flora van Vlaanderen en het Brussels Gewest. Brussel & Meise, INBO, Nationale Plantentuin van België & Flo.Wer.

Vignon F. (1982) — Troisième série de precartes de l'Institut floristique franco-belge. *Documents floristiques* **III (1-2-3)**: 43-203.

Wiinstedt K. (1927) — En graesplaeneflora i Herregaardsparker. Flora og Fauna. Naturhistorisk Museum, Denmark.

Zerbe S., Maurer U., Peschel T., Schmitz S. & Sukopp H. (2004) — Diversity of flora and vegetation in European cities as a potential for nature conservation in urban-industrial areas with examples from Berlin and Potsdam (Germany). *In* Shaw W.W. *et al.*, Proceedings 4th International Urban Wildlife Symposium, May 1-5 1999, Tucson, Arizona: 35-49. [Accessed as pdf: http://cals.arizona.edu/pubs/adjunct/snr0704/snr07041e.pdf]

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Short note

Landoltia punctata and *Lemna aequinoctialis* (Lemnaceae) in the greenhouses of the Botanic Garden

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Scripta Bot. Belg. **47**: I. Hoste (ed.), The spontaneous flora of the National Botanic Garden of Belgium (Domein van Bouchout, Meise)

Résumé. – ***Landoltia punctata* et *Lemna aequinoctialis* dans les serres du Jardin botanique national de Belgique**. Depuis quelques années des populations mixtes de *Landoltia punctata* et *Lemna aequinoctialis* se maintiennent spontanément dans les serres du Jardin botanique a Meise. Cette note donne une breve description des deux especes et pose la question sur la probabilite d'une naturalisation hors des serres.

Samenvatting. – ***Landoltia punctata* en *Lemna aequinoctialis* in de kassen van de Nationale Plantentuin van België**. Sinds enkele jaren handhaven zich gemengde populaties van *Landoltia punctata* en *Lemna aequinoctialis* spontaan in de kassen van de Nationale Plantentuin in Meise. Deze nota beschrijft beknopt de beide soorten en gaat in op de vraag hoe groot de kans is dat ze buiten de kassen zouden inburgeren.

Since a number of years more or less stable populations of Lemnaceae are thriving in cisterns under the tablets in several different greenhouses at the National Botanic Garden of Belgium in Meise. With the naked eye two types of plants are immediately recognizable. One type has small bright green, rather narrow fronds, whereas the other one has somewhat larger, light green fronds. The first type dominates the vegetation, with the second one usually represented by small clusters of fronds only. Naming the plants with the Western European field flora's proved impossible. Without major problems, however, both species could be identified as *Landoltia punctata* (G.Mey.) D.H. Les & D.J. Crawford (the smaller species) and *Lemna aequinoctialis* Welwitsch (the larger one) when using the Lemnaceae monograph published by Landolt (1986). None of these non-indigenous species has previously been reported from Belgium. In 2007 John Bruinsma collected and identified *L. aequinoctialis* in the Victoria greenhouse of the Botanic Garden too.

Landoltia punctata [syn.: *Spirodela punctata* (G.Mey.) Thompson] has rather narrow, bright green, usually shining fronds with at least three clearly visible veins, and often with a purple edge. The median line of the fronds has a row of small papillae. At the underside the fronds vary from green to purple. The plants usually have several roots, but in the plants I observed in the Botanic Garden the number was often reduced to a single root (observation August 2009); Landolt (1986) mentions this is not really unusual with plants growing in less favorable circumstances. See for more information on this species Van Valkenburg & Pot (2007-2008), and for some high quality photographs http://waynesword.palomar.edu/lwayindx.htm.

On the upper side the thin oblong fronds of *Lemna aequinoctialis* are rather dull, with three clearly visible veins. Each frond has a single root. At the Botanic Garden the fronds are usually rather large (c. 4.5-5 mm long, observations August 2009). Along the median line papillae can be seen only near the apex and just above the root. Typically the species of section Alatae, which further only includes the smaller *L. perpusilla*, have a winged root base. This is

best observed on fresh plants, immediately after the water covering the frond has dried up.

In Western Europe neither of both species seems to be on its way to become naturalized. In the past few years *Landoltia punctata* has repeatedly been observed in pet shops selling aquarium plants in the Netherlands, and occasionally also outdoors in the vicinity of a garden centre (van Valkenburg & Pot 2007-2008). In the Netherlands *L. aequinoctialis* has some years ago been recorded as a weed from a garden centre that sells water and riparian plants. A transplanted population from this site survived through the winter 2005-2006 in a garden pond, but disappeared completely during the summer of 2006 (obs. J. Bruinsma, April 2008).

People have spread both species far outside their natural ranges (Landolt 1986). The plants being small and inconspicuous, they are easily dispersed as stowaways when ornamental water plants are sold and transported. This is presumably also how they initially entered the Botanic Garden greenhouses. In the greenhouses they thrive while they are tolerated as benign weeds in the cisterns. Both species are naturally restricted to somewhat warmer (*L. punctata*) or even tropical (*L. aequinoctialis*) climates. In the greenhouses they find suitable conditions for survival, but the chances for spontaneous dispersal and spread outside the greenhouses are probably slim. Therein they differ from *Lemna minuta*, originally from temperate North and South America, which since 1965 has been spreading as a successful alien in large parts of Western Europe (Landolt 1986). When it is taken into account that *Landoltia punctata* or *Lemna aequinoctialis* are (only infrequently?) used as aquarium plants, and that they are often present in containers with water plants in garden centres, future outdoors records are to be expected. However, whether they have the potential to persist or naturalize in these conditions remains doubtful.

References

Landolt E. (1986) – Biosystematic investigations in the family of duckweeds (Lemnaceae). Vol. 2. *Veröff. Geobot. Inst. ETH Zürich* **71**.

van Valkenburg J. & Pot R. (2007-2008) – Landoltia punctata (G. Mey.) D.H. Les & D.J. Crawford (Smal kroos), nieuw voor Nederland. *Gorteria* **31**: 41-49.

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Short note

Fumaria parviflora in Belgium, extinct or not?

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Résumé. – *Fumaria parviflora* en Belgique: disparu ou non? Quelques plantes de *Fumaria parviflora*, une espèce considérée comme disparue de Belgique, ont été observées dans le Domaine du Jardin botanique. Leur origine probable est discutée, ainsi que la présence ancienne de cette espèce en Belgique.

Samenvatting. – *Fumaria parviflora* in België: verdwenen of niet? Enkele planten van *Fumaria parviflora*, een soort die beschouwd wordt als verdwenen uit België, werden in het Domein van de Nationale Plantentuin aangetroffen. Hun mogelijke herkomst wordt besproken, evenals het vroegere voorkomen van de soort in België.

One plant of *Fumaria parviflora* was found growing as a weed in the herbetum (sector 51) at the National Botanic Garden of Belgium in 2007, and another plant at the same location in 2009. *Fumaria parviflora* is an annual arable weed of calcareous soils. It is considered an archaeophyte in Belgium (Ronse 2006), although it is close to the northern border of its distribution.

It has always been rare in Belgium, where, according to Van Rompaey & Delvosalle (1979), about ten locations have been found, scattered throughout the country, before 1930. However, according to the *Atlas van de flora van Vlaanderen en het Brussels Gewest* (Ronse 2006), it was recorded from only one location in the period from 1939 to 1971. This was in IFBL square E4.16, not far from the Domain of the Botanic Garden that lies in IFBL square D4.55. This record is supported by a herbarium specimen from F. Michel, 22.06.1944, "décombres à Haren". There is also an earlier specimen from Diegem (IFBL E4.17: A. Verhulst, 07.1910).

Fumaria parviflora is considered extinct according to the red lists for Flanders and Wallonia (Van Landuyt *et al.* 2006; Sainte-noy-Simon *et al.* 2006). In Flanders it was not recorded between 1972 and 2004. It has been recorded during the seventies in Wallonia, as supported by a specimen in the BR herbarium (P. Diederich, 24.07.1976, "bord de l'Eisch, hêtraie au bord d'un ruisseau canalisé, près de Steinfort" IFBL L8.51).

In total, the BR herbarium contains only 35 specimens of *F. parviflora*, although only 21 have a clear locality. Only one site, Tournai, has multiple collections over multiple years. Twelve specimens from Tournai span only 21 years between 1864 and 1885. From the notes on one of these specimens it was apparently abundant in at least one site near Tournai during this period. From all other sites there is no evidence that the specimens were anything more than isolated individuals, the result of casual introduction.

As the species is so rare and as there is no mention of it since the seventies [1976], we had a strong suspicion that its presence at Meise was due to an escape from the collections of the Botanic Garden. In the computerized records of the living collections, we found no trace of the cultivation of *F. parviflora* in the Garden. Though, these records only mention plants that have either been introduced into the collection since 1990 or plants from former introductions that were still living at that time.

However, in the herbarium of the cultivated species of the Garden we found a specimen that proves its cultivation in the garden: E. Mommaerts, A56, sept. 1974, "cultivé". There is no mention of where exactly it was grown, but it was probably cultivated in sector 39, where the annuals were sown at the time. At that time, the herbetum did not exist. We have searched the introduction books for 1972 to 1974, but *F. parviflora* is not listed. So we suppose that it was in cultivation before 1972 and at least until 1974 when the herbarium specimen was made. It must have disappeared from the collection sometime before 1990.

So it is possible that the plants found in the herbetum originate from these cultivated plants, although this hypothesis still raises the question on how they reached the herbetum. It might be that the species was planted there when the herbetum was laid out in 1976, or it could have been introduced unwittingly as a seed contaminant.

A second hypothesis, however, is that the plants have been brought in as weeds from an external source. Indeed, Hoste *et al.* (2009) has recently found that *Fumaria parviflora* is amongst species regularly present as weeds in Mediterranean container plants in Belgian garden centres. The species is rather common not only in the Mediterranean, but also in many parts of France, and these are the native ranges of many plants in the herbetum. It also occurs as an introduced weed in California and Australia.

To summarize, there is little evidence of a self-sustained Belgian population of *F. parviflora*, at least since 1930. All recent sites have been transitory. Indeed, the evidence that *F. parviflora* has ever had self-sustaining populations in Belgium is scant, except for at Tournai. Certainly, most of the known records do not occur on chalky soils, the classic habitat of this species, except that is for Tournai. So although self-sustaining populations of *F. parviflora* are apparently extinct in Belgium, it is debatable whether it was ever well established in the country.

References

Hoste I., Verloove F., Nagels C., Andriessen I. & Lambinon J. (2009). De adventiefflora van in België ingevoerde mediterrane containerplanten. *Dumortiera* **97**: 1-16.

Ronse A. (2006). Fumaria parviflora. *In* Van Landuyt W. *et al.*, Atlas van de flora van Vlaanderen en het Brussels Gewest. Brussel-Meise: INBO, Nationale Plantentuin van België & Flo Wer.

Saintenoy-Simon J. (coll. Barbier Y., Delescaille L.-M., Dufrêne M., Gathoye J.-L. & Vertz P.) (2006). Première liste des espèces rares, menacées et protégées de la Région Wallonne (Pteridophytes et Spermatophytes). Version 1 (7-3-2006). [http://biodiversite.wallonie.be/especes/ecologie/plantes/listerouge.]

Van Landuyt W., Vanhecke L. & Hoste I. (2006). Rode Lijst van de vaatplanten van Vlaanderen en het Brussels Hoofdstedelijk Gewest. *In* Van Landuyt W. *et al.*, Atlas van de flora van Vlaanderen en het Brussels Gewest. Brussel-Meise: INBO, Nationale Plantentuin van België & Flo Wer.

Van Rompaey E. & Delvosalle L. (1979). Atlas van de Belgische en Luxemburgse flora. 2de uitgave. Meise: Nationale Plantentuin van België.

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Short note

Expansion of the alien *Ranunculus parviflorus* in the Botanic Garden

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Résumé. – Expansion de l'espèce adventice *Ranunculus parviflorus* dans le Jardin botanique. *Ranunculus parviflorus*, espèce originaire de l'Europe du Sud-ouest, a été observée quelques fois en Belgique comme adventice. Il est connu comme espèce invasive sur plusieurs continents et a été trouvé à plusieurs endroits dans le Domaine du Jardin botanique, il s'y est très probablement échappé des collections, d'où il a disparu entretemps.

Samenvatting. – Uitbreiding van de adventieve *Ranunculus parviflorus* in de Plantentuin. *Ranunculus parviflorus*, uit Zuidwest-Europa, werd in België al enkele keren als adventief aangetroffen. De soort is in meerdere werelddelen gekend als invasieve exoot. Ze werd op meerdere plaatsen in het Domein gevonden, en is er hoogstwaarschijnlijk ontsnapt uit de levende collecties, waaruit ze inmiddels verdwenen is.

Ranunculus parviflorus L. (Ranunculaceae) is a low (max. 35 cm high) pioneer species that thrives in disturbed soils such as in arable fields. It can also grow on non-disturbed grounds, but these are mostly shallow soils that are arid in summer, where other species cannot attain a sufficient stature to overshadow it. The small flowers have between zero and five, and mostly two petals. As a winter annual *R. parviflorus* shows a delayed and simultaneous germination in September, and forms a leaf rosette in the late autumn. Under experimental conditions in Great Britain the flowering period extended from April to June, but it may be shorter in natural habitats, owing to the drying up of the plants. The achenes usually ripen and are shed from mid-May to mid-July (Salisbury 1931). The achenes are covered by hook-shaped spines that allow zoochorous seed dispersion. Though the natural habitats may be dry during the fruiting period, and sometimes extremely so, they must be sufficiently moist during the winter for the plant's development.

R. parviflorus has a typical Atlantic distribution in Europe: it is native to the Mediterranean region and Southwest Europe. Its northern limit reaches Great Britain and Southwest France in its western part (Salisbury 1931; Bock 1979), and only reaches North Italy in its eastern part (Jalas & Suominen 1989). This means that Belgium lies outside its distribution range. The species is naturalized in subtropical to temperate areas of North and South America (Benson 1948; Hernandez 1993) and in Australia and New Zealand (Bock 1979), where it occurs in arable land, vineyards, pastures and waste places.

In Belgium, *R. parviflorus* has been recorded as an adventive species since 1950 (Verloove 2006). Moreover, a search in the herbarium of the National Botanic Garden (BR) has shown that two older specimens from the nineteenth century are present too, both from Wallonia: one is from near Tournai (coll. Westendorp, s.d.), the other one from near Jambes (Marcq and Piret 1894). In 1950 the species was collected by A. Lefebvre in the dunes at De Panne (Flanders), where it was abundant. More recently, in 1999 a large and increasing population was found in a moist pasture in Merlegem-Zwalm (Flanders) by Br. J. De Ruy-

ver (herb. BR). It is not known whether it is still present in this locality.

In the Botanic Garden in Meise *R. parviflorus* has been found in six sectors, scattered over the southern half of the Domain (fig. 1). Since 2008 it has been recorded from an increasing number of sectors. It is not present in the living collections, but from the database records we learn that it has been cultivated between 1974 and 1992; after that year it has disappeared from the collections. By then it must have escaped from the collections, and have persisted as a weed ever since, initially perhaps only in sector 39, where it had been cultivated, and where recently it has occasionally been found as a weed. By then it probably had also settled in the neighboring nursery sectors 40 and 42, where today it is an annoying weed. Despite active control, the species covers many square metres at the edge of the nurseries and on unpaved paths. It has been a weed there for many years according to the gardeners. The nurseries are only about 50 m away from the sector where *R. parviflorus* was planted, and all these sectors are cultivated by the same gardeners. So it is plausible that the seeds were unwittingly spread by the gardeners from one place to another.

Figure 1. Location of the sectors in the Domain of the Botanic Garden where Ranunculus parviflorus has been found. Hatched: sectors where the species has been recorded from the living collections; white dots: sectors where it was cultivated between 1974 and 1992; black dots: sectors where it occurs as a weed.

In 2008 a few plants of *R. parviflorus* were found about 200 m further downhill from the above mentioned sectors, on the edge of a moist lawn. The same year several plants were also discovered in the edge of lawns and of plant beds in the fruticetum, some 400 m away from the original location (herbarium A. Ronse n°1465). In 2009 another population with numerous plants was found against the walls at the southern side of the castle (sector 13), this is about 500 m away from the initial sector 39. Here again, the seeds may have been carried by gardeners, or they might have been carried by the numerous geese that permanently graze the lawns of the Domain.

The expansion within the Botanic Garden shows the propensity of the species to proliferate, be it on a relatively small scale. In many countries it has shown an invasive character outside its native range. As notified by several websites, including the Global Compendium of Weeds (http://www.hear.org/gcw/species/ranunculus_parviflorus), *R. parviflorus* is naturalized in Southeast Australia, New Zealand and Tasmania, Hawaii, and Chile. It is established as a weed in many states of the USA (http://plants.usda.gov/java/profile?symbol=RAPA3). One of the factors explaining the success of the species is probably the high seed output, with up to 6,700 achenes produced per plant on fertile soils, 246 achenes being the average in wild populations (Salisbury 1931).

R. parviflorus is susceptible to frost, and the fact that only few seeds enter the soil seed bank makes it vulnerable to severe winters. On some localities in Southwest Britain it has been exterminated in the past by severe weather (Salisbury 1931). On the other hand, seeds appear to be long-lived, and populations may reappear after disturbance or persist for many years. To the north of its historical distribution in Britain, as well as in Ireland, the species is considered alien to many recently discovered localities (Fitzgerald 2002). If one compares the European distribution map in Jalas & Suominen (1989) with the plant hardiness zones, it is obvious that the species mainly occurs in hardiness zone 9 and parts of zone 8. The north

of Belgium falls within zone 8, but this has proved too cold for this species in the past. In Meise however, the species has survived for nearly twenty years, and has even expanded. Furthermore, a second locality has appeared about ten years ago in Flanders, as mentioned above. It is tempting to link this with Global Warming.

If the species manages to establish permanent populations, it is time to ask whether it could perhaps become a threat to native species. *R. parviflorus* mainly occurs in disturbed places that usually have a low nature conservation value. However, it also grows on poor soils in thermophilous vegetations, where it can compete with native species. It has, however, been shown to produce much less seeds in these circumstances, and given its susceptibility to frost, the threat to such habitats is probably restricted.

Literature

Benson L. (1948) – A treatise on the North American Ranunculi. *Amer. Midl. Nat.* **40(1)**: 1-261.

Bock C. (1979) – Ranunculus parviflorus L. dans le bois de Beynes (Yvelines). *Cahiers des Naturalistes, ns* **34(2)**: 79-81.

Fitzgerald R.A. (2002) – Ranunculus parviflorus, Small-flowered buttercup. *In* Preston C.D. *et al.*, New Atlas of the British & Irish flora. Oxford, Oxford Univ. Press.

Hernandez H. (1993) – Ranunculus parviflorus L. (Ranunculaceae), especie adventicia en la Argentina. *Lilloa* **38(1)**: 117-119.

Jalas J. & Suominen J. (1989) – Atlas Florae Europaeae, vol 8. Nymphaeaceae to Ranunculaceae. Helsinki, The Committee for Mapping the Flora of Europe & Societas Biologica Fennica Vanamo.

Salisbury E.J. (1931) – On the morphology and ecology of Ranunculus parviflorus L. *Annals of Botany* **45**: 539-578.

Verloove F. (2006) – Catalogue of neophytes in Belgium (1800-2005). *Scripta Bot. Belg.* **39**. Meise, National Botanic Garden of Belgium.

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Galanthus nivalis in de Nationale Plantentuin: een mix van archeofyten en stinsenplanten

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Scripta Bot. Belg. **47**: I. Hoste (ed.), The spontaneous flora of the National Botanic Garden of Belgium (Domein van Bouchout, Meise)

Abstract. – *Galanthus nivalis* in the Domain of the National Botanic Garden: a mix of archaeophytes and stinsen plants. The status of *G. nivalis* in Belgium is uncertain. In the Domain of the Botanic Garden two types of plants are found. The small plants that are mostly found growing under former coppice are probably archaeophytes, although populations in other parts of the Domain are 19th-century introductions, probably from Germany. The larger plants, which easily set seed, are stinsen plants, originating from possibly indigenous populations elsewhere in Belgium.

Résumé. – *Galanthus nivalis* dans le Domaine du Jardin botanique national: un mélange d'archéophytes et de plantes castrales. Le statut de *G. nivalis* en Belgique est incertain. Deux types de plantes sont présents dans le Domaine du Jardin botanique. Le type de taille réduite, qui pousse principalement dans les taillis, est considéré comme une archéophyte ; d'autres populations ailleurs dans le Domaine ont probablement été introduites d'Allemagne au 19e siècle. Le type de grande taille, qui produit des graines en abondance, est une plante castrale, originaire de populations belges éventuellement indigènes.

Inleiding

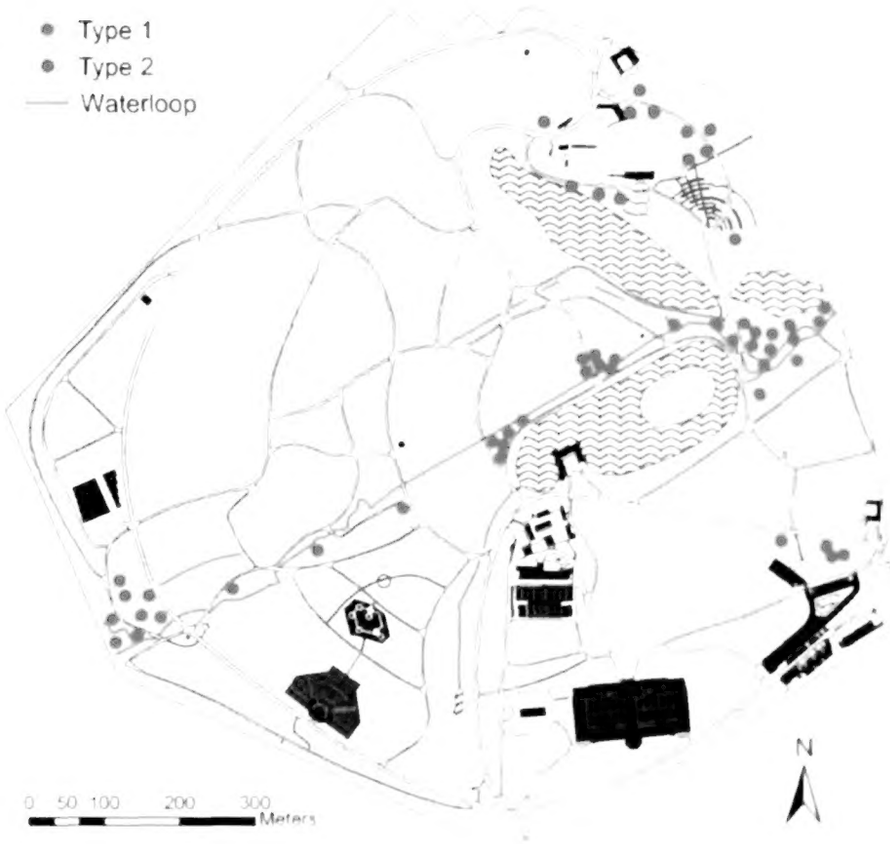
Vanaf eind februari lichten, verspreid over het Domein van de Plantentuin, witte vlekken van duizenden sneeuwklokjes de grauwe winterse bodem op. Het betreft hier het gewone sneeuwklokje of *Galanthus nivalis*, een soort die verspreid over het Domein voorkomt (Fig. 1).

Het in 1999 verschenen boek *The Genus Galanthus* van Aaron P. Davis is momenteel de internationale standaard voor de naamgeving van de taxa van het geslacht *Galanthus*. De door ons gehanteerde naamgeving is ontleend aan deze monografie.

Galanthus nivalis is een bijzonder variabele soort. In het verleden was men geneigd elke variant als een ondersoort te benoemen, wat uiteindelijk leidde tot onoverzichtelijk lange namenlijsten. Vandaag echter is er een tendens tot 'lumping'. We zullen er ons in deze bijdrage niet aan wagen de beschreven vormen te verbinden met precieze namen. Voor het hier beoogde doel is dit ook niet echt noodzakelijk, en zonder gericht onderzoek in een geografisch veel ruimere context lijkt het ons momenteel bijzonder moeilijk om op dit punt betrouwbare uitspraken te doen.

Inheems? De standaard Flora's twijfelen

De vraag of het sneeuwklokje al dan niet inheems is in België, komt sinds de 19de eeuw in de Belgische Flora's geregeld aan bod. In de eerste editie van zijn *Manuel de la flore de Belgique* somt Crépin (1860) een reeks plaatsen op waar het sneeuwklokje werd waargenomen. Hij voegt daar echter onmiddellijk aan toe: "Les localités citées sont trop suspectes pour pouvoir considérer cette plante comme indigène." In de tweede editie van de *Manuel*, uit 1866, somt Crépin een groter aantal vindplaatsen op en nuanceert hij zijn conclusie uit de eerste editie: "Il est probable que dans plusieurs de ces stations la plante est introduite." De



Figuur 1. Verspreiding van sneeuwklokjes (Galanthus nivalis) *van het 'type 1' en 'type 2' in het Domein van de Nationale Plantentuin, in kaart gebracht in de lente van 2009. De planten van het type 1 komen vooral voor onder hakhout, terwijl type 2 vooral gevonden wordt in de omgeving van de oranjerietuin. Zie verder de tekst voor een beschrijving van de types 1 en 2.*

auteur laat met andere woorden de mogelijkheid open dat minstens een gedeelte van de populaties inheems kan zijn. In de derde tot vijfde editie van de *Manuel* (1874,1882 en 1884) is geen opmerking meer toegevoegd en ontbreekt het symbool dat doorheen de hele Flora gebruikt wordt om aan te duiden dat een soort niet behoort tot de oorspronkelijke wilde flora. *Galanthus nivalis* krijgt voortaan de status van een inheemse soort.

In de opeenvolgende edities van zijn *Nouveau Manuel de la Flore de Belgique et des regions limitrophes* lijkt Gotfart (1934 e.v.) zich aan te sluiten bij de conclusie van Crépin. We vermoeden inderdaad dat de vermelding "subspontané?" alleen betrekking heeft op de vermelde vindplaats in het Groothertogdom Luxemburg, en dat Gotfart de soort als inheems weerhoudt voor België en Noord-Frankrijk.

Een paar decennia later gaat het met de interpretatie opnieuw de andere kant op. De Flora van De Langhe *et al.* (1967) noteert kortweg "Plante probablement naturalisee", een vermelding die nadien gekopieerd wordt in de eerste en tweede editie van de *Nouvelle Flore* (De Langhe *et al.* 1973, 1978). In de derde, vierde en vijfde editie van de *Nouvelle Flore* (1983, 1992 en 2004) wordt de twijfel nog iets versterkt: "Plante probablement seulement naturalisee." De twijfel is ingegeven door de vaststelling dat de grenzen van het natuurlijke areaal van *G. nivalis* globaal zeer onvoldoende gekend zijn. De soort kan daarom in België het best omschreven worden als een al eeuwenlang ingeburgerde archeofyt.

Inheems of archeofyt: de huidige visie

Vandaag wordt aangenomen dat de noordgrens van het natuurlijke verspreidingsareaal van *Galanthus nivalis* ongeveer tot rond 50 NB reikt. Deze breedtegraad loopt dwars door Wallonië. De kaart die het best de verspreiding van *G. nivalis* weergeeft, werd gepubliceerd door Paul von Gotthieb-Tannenhain (1904), zie fig. 2. Vraag is echter of er voldoende elementen zijn om, zoals op die kaart is gebeurd, bepaalde delen van België te weerhouden als onderdeel van het natuurlijke verspreidingsareaal. Die vraag dient met name gesteld met betrekking tot het Leemplateau van het Brabants floradistrict, een gebied waar *G. nivalis* vandaag

Figuur 2. De verspreiding van Galanthus nivalis *in het westelijke gedeelte van het natuurlijke verspreidingsgebied, ontleend aan de publicatie van von Gottlieb-Tannenhain (1904)*

frequent spontaan voorkomt. De *Atlas van de Flora van Vlaanderen en het Brussels Gewest* (Van den Bremt 2006) geeft een groot aantal nieuwe vindplaatsen aan in vergelijking met eerdere karteringen. De auteur merkt op dat tijdens vroeger karteringswerk de Leemstreek ten westen van Brussel zwak geïnventariseerd werd, wat de plotse recente 'toename' grotendeels verklaart.

Een groot aantal vindplaatsen ligt in de grensstreek tussen Oost-Vlaanderen en Henegouwen, met een uitloper in de Zwalmstreek. In het kader van deze bijdrage over de flora van het Domein van de Nationale Plantentuin is een groot aantal van de in de plantenatlas vermelde locaties bezocht. We stelden vast dat de meeste vindplaatsen op het Brabantse Leemplateau ten westen van Brussel ver van historische nederzettingen, zoals abdijen en kastelen, liggen. Het betreft doorgaans locaties die elders in Europa als 'natuurlijk' worden omschreven, namelijk bosranden, beekvalleien en vochtige weiden.

Bovendien zijn de huidige groeiplaatsen in Henegouwen en de Zwalmstreek weinig of niet onderhevig geweest aan ruilverkaveling, industrialisatie en verstedelijking. Door deze ingrepen zijn in de loop van de twintigste eeuw vooral in Vlaanderen talrijke beken rechtgetrokken, vergraven en/of sterk vervuild geraakt door fosfaat- en stikstofrijk afvalwater. Dit wordt bevestigd door een publicatie van Daems & Slembrouck (1991), die in de provincie Antwerpen locaties bezochten die vijftig jaar eerder door Joseph-Edgard De Langhe beschreven waren en waar toen *Galanthus nivalis* groeide.

Sneeuwklokjes zijn, net als heel wat andere voorjaarsbloeiers, zeer gevoelig voor bodemverdichting en te stikstofrijke bodems. Daarom kunnen we ervan uitgaan dat *G. nivalis* bij de aanvang van de 20ste eeuw in Vlaanderen veel algemener voorkwam dan vandaag. Interessant is dat De Langhe (1991) wijst op de morfologische variatie van het sneeuwklokje. Net zoals wij dat kunnen doen bij de planten in de Plantentuin, maakte De Langhe een onderscheid tussen enerzijds een forser en breder type en anderzijds een smal, fijn type, waarbij op één vindplaats ook *Galanthus nivalis* var. *scharlokii* voorkwam. Een gelijkaardige morfologische variatie komt ook voor in het Domein van de Plantentuin en wordt verder besproken.

Uit eigen kunsthistorisch onderzoek blijkt dat afbeeldingen van *G. nivalis* vanaf de late 14de eeuw frequent en duidelijk herkenbaar voorkomen op Doornikse tapijten, en vanaf de 16de eeuw ook op de bloemenstillevens van Brusselse schilders als Jan Brueghel de Oude. Op artistiek vlak moet men wachten tot de late 16de en vooral de 17de eeuw alvorens het sneeuwklokje in Vlaanderen algemeen voorkomt op schilderijen en tapijten van de verschillende toonaangevende kunsteentra; een publicatie hieromtrent is momenteel in voorbereiding.

Wat voorafgaat lijkt de juistheid van de kaart in von Gottlieb-Tannenhain (1904) te bevestigen. Gelet op de grote verschillen tussen de 'in het wild' voorkomende populaties, is de werkelijkheid echter complexer dan dat. Vooraleer we kunnen beslissen tot 'inheems', moeten we eerst dieper ingaan op de problematiek van 'inheemse populaties', 'verwilderde tuinplanten' en 'archeofyten'. België is slechts een kleine vlek op de Europese kaart, maar precies hier

situeren zich interessante overgangs- en grenszones tussen uiteenlopende verspreidingsarealen. In de Brusselse rand is het Domein van de Plantentuin een relictgebied met natte zones en beekvalleien met voormalige hakhoutbossen, die in de loop van de 20ste eeuw gespaard zijn gebleven van kanalisatie en zware vervuiling. Precies in die relictzones kunnen we twee morfologisch duidelijk verschillende types van *Galanthus nivalis* onderscheiden, die allebei in grote aantallen voorkomen.

Twee types planten in de Plantentuin

De in de Plantentuin aanwezige populaties van *Galanthus nivalis* kunnen herleid worden tot twee types van planten.

Het eerste type wordt vooral aangetroffen in vochtig hakhout en in het historische park rond het kasteel van Bouchout (fig. 1). Het betreft een eerder klein sneeuwklokje dat laat in het seizoen bloeit, van half februari tot half maart. Het heeft de volgende kenmerken:

- vrije bladlengte 90 tot 110 mm;
- bladbreedte ± 5 tot 6 mm;
- bladlengte ± 90 tot 110 mm (of ± 130 tot 150 mm, tot aan knol, m.a.w.: gedeelte omhuld door de manchet inbegrepen);
- bladkleur donkergroen;
- manchet witgroen en 30 mm hoog;
- bloemsteeel (gemeten boven de manchet) 100 tot 130 mm; de bloemen komen amper boven het blad uit;
- buitenste bloemblad ± 25 mm lang en ± 5 mm breed, soms voorzien van een groen merk langs de buitenzijde;
- de bloemblaadjes staan mooi bol wanneer het klokje zich opent bij temperaturen boven 11 °C;
- binnenste bloemblad ± 10 mm lang en ± 4 mm breed, voorzien van een klein, groen, V-vormig merkteken;
- bloeit laat in het seizoen, in de regel van half tot half februari tot half maart;
- weinig of geen waarneembare honinggeur wanneer de temperatuur boven 11 °C stijgt, de planten worden weinig of niet bevlogen door insecten;
- spontane zaadvorming zwak of ontbrekend, maar wel zeer goede (100 %!) zaadvorming na manuele bestuiving (beperkte proef met 10 bloemen).

Het tweede type planten wordt aangetroffen in het voormalige domein van Meise. Het zwaartepunt van de verspreiding ligt rond de oranjerie van de Plantentuin (fig. 1). De planten van dit type vertonen de volgende kenmerken:

- vrije bladlengte ± 205 tot 250 mm;
- bladbreedte 11 tot 12 mm;
- bladlengte ± 205 tot 250 mm (of inclusief manchet ± 235 tot 280 mm);
- bladkleur donkergroen, met blauwgroene schijn;
- manchet witgroen en 30 mm hoog;
- bloemsteel (gemeten boven de manchet) 230 tot 280 mm;
- binnenste bloemblad ± 27 mm lang en ± 7 mm breed;
- buitenste bloemblad ± 12 mm lang en 5 mm breed, voorzien van een klein, groen, V- tot hartvormig merkteken;
- bloeit net als type 1 zeer laat in het seizoen, vaak zelfs net nog iets later, in de regel van de tweede helft van februari tot eind maart.

De beide types onderscheiden zich morfologisch vooral door hun grootte en door de zaadvorming. Overvloedige zaadvorming komt vooral voor bij de grote planten van het type 2 (fig. 3); de forsere bloemen van dit type worden in maart goed bevlogen door hommels en bijen. In tegenstelling tot de planten van type 1 steken de bloemen een heel stuk boven het blad uit. Ook is bij planten van type 2 een duidelijke honinggeur waarneembaar wanneer de temperatuur tot boven 11 °C stijgt. Precies zoals bij de bloemen van type 1 leidt manuele bestuiving met een penseel tot heel goede (100 %!) zaadvorming bij planten van type 2 (beperkte proef met 10 bloemen).

Type 1: verspreiding en ecologie

Type 1 wordt in de Plantentuin in hoofdzaak aangetroffen in het broekbos, een zone die de voorbije eeuwen weinig of niet vergraven is. Waarschijnlijk betreft het een archeofyt (of

Figuur 3. Rijke en spontane zaadvorming bij planten van het type 2. (Foto S. Vidts, Nationale Plantentuin, 30.04.2009)

misschien zelfs een inheemse populatie). Dit type niet geurende sneeuwklokjes met eerder kleine bloemen en klein blad wordt ook aangetroffen in gelijkaardige broekbossen in de Leemstreek rond Zwalm en Brakel. Net als in de Plantentuin zetten deze sneeuwklokjes er slechts beperkt spontaan zaad. De bollen worden vooral verspreid door het water: bij overstromingen brokkelen de beekoevers af en voert het water losgekomen bollen mee. In historisch perspectief is het belangrijk aan te stippen dat varkenshoeders de grond in deze hakhoutbossen in september en oktober regelmatig lieten omwoelen door varkens op zoek naar noten en eikels (Tack *et al.* 1993).

Het is opvallend dat de bollen van het type 1, dat in de Plantentuin voorkomt in het broekbos langs de Molenbeek, zeer ondiep wortelen. De oppervlakkige positie van de bloembollen heeft waarschijnlijk te maken met het vochtige milieu, waarbij de bollen zich zo oppervlakkig mogelijk situeren tussen het gecomposteerde blad. De oppervlakkige positie en het gewoel van de varkens zorgden er in het verleden voor dat de bollenclusters werden gedeeld en de individuele bollen zich beter konden verspreiden. Dit is misschien ook een van de redenen waarom deze sneeuwklokjes weinig of geen honinggeur verspreiden: zaadzetting is voor dit type minder belangrijk. Bij deze sneeuwklokjes is met andere woorden sprake van specialisatie in de richting van vegetatieve vermeerdering.

Wanneer geen zaad wordt gevormd, gaan sneeuwklokjesbollen zich in 2 tot 5 bollen opsplitsen. Dit leidt op termijn tot polvorming, wat kan leiden tot verstikking. Te dichte pollen stimuleren sneeuwklokjessmeul, een plantenziekte veroorzaakt door een schimmel van het genus *Botrytis*. Naast het opkuisen van de bosbodem en het voorkomen van een te rijke opkomst van jonge bomen, zorgde in het najaar het omwoelen van de grond door varkens ook voor de verspreiding van de sneeuwklokjesbollen. (Fig. 4)

Figuur 4. In Schotland worden op de Cambo Estate sinds enige tijd opnieuw varkens ingezet om in het vochtige valleibos de pollen sneeuwklokjes op een efficiënte wijze te scheuren. Ook wordt zo voorkomen dat de dichte klimopbegroeiing op de bodem de voorjaarsbollen versmacht. (Foto S. Vidts)

Vertrekkend van de voorgaande redenering, kan men stellen dat de sneeuwklokjes van het type 1 te beschouwen zijn als een archeofyt, waarvan de verspreiding duidelijk verband houdt met het beheer van het hakhoutbos, en in het bijzonder met het hoeden van varkens in het bos. Het is frappant dat vandaag in dit broekbos veel dichte pollen voorkomen die bijna alle te lijden hebben van smeul. De kans is reëel dat deze populatie hier op termijn zal teruglopen.

Herkomst van de planten van type 1 in de Plantentuin

Een gedeelte van de sneeuwklokjes van het type 1 is vermoedelijk tijdens de tweede helft van de 19de eeuw, wanneer Bouchout bewoond werd door de familie de Beauffort en nadien Keizerin Charlotte, uitgeplant in andere delen van de historische tuin. We denken bijvoorbeeld aan de omgeving van de eredreef. In dit beduidend minder drassige milieu lijken de sneeuwklokjes het vandaag beter te doen in vergelijking met hun oorspronkelijke groeiplaats, maar ook hier vormt type 1 weinig of geen zaad. Vandaag wordt in die omgeving een extensief maaibeheer toegepast. De maaibalk die het gras in juli kort zet botst tijdens het werk geregeld tegen de grond, wat wellicht mee tot gevolg heeft dat bollenclusters worden opengebroken.

Tijdens de periode van de keizerin, eind 19de eeuw, werden in het Domein ook sneeuwklokjes geïntroduceerd van buitenaf. Naast het 'lokale' type 1 vindt men op enkele plaatsen *G. nivalis* 'Flore Pleno' (het dubbele sneeuwklokje) en *G. nivalis* var. *scharlokii* (bloembladjes met groene punten). De groeiplaatsen van deze planten situeren zich vandaag vooral buiten de grenzen van de huidige Plantentuin. Tijdens de tweede helft van de 20ste eeuw werd, zoals in elk openbaar groendomein, intens gebruik gemaakt van chemische meststoffen en herbiciden. Chloorhoudende meststoffen zijn nefast voor populaties van voorjaarsbloembollen, en waarschijnlijk is dit de reden waarom in de ruigten en resterende boomgroepen en parkbosfragmenten in het gebied tussen de A12 en de Nieuwelaan vandaag de grootste variatie in type 1 wordt aangetroffen. Bij het begin van de 20ste eeuw reikte het private park van Keizerin Charlotte tot over de huidige A12.

De 19de-eeuwse introducties zijn waarschijnlijk van Duitse oorsprong, meer bepaald uit het Eifelgebergte en het Rijngebied, waar dergelijke sneeuwklokjes courant voorkomen (Davis 1999, von Gottlieb-Tannenhain 1904). Eind 19de en begin 20ste eeuw waren in Duitsland verschillende firma's actief die zaden en voorjaarbloembollen exporteerden voor de aanleg van 'natuurlijke' romantische tuinen; zie hieromtrent bv. Ronse & Leten (2011), die de introductie van zogenaamde bosgazonneofyten of 'wood lawn neophytes' in het Domein beschrijven. De van buiten het Domein geïntroduceerde planten verschillen van het 'lokale' type 1 door de groene vlekken langs de buitenzijde van de buitenste kroonbladeren, ook zijn de planten iets groter en forser dan het hier beschreven broekbostype. De buitenste bloembladen zijn bij volledig open bloemen in de regel ook meer gestrekt. Deze introducties gedragen zich vandaag als gemakkelijk verwilderende sierplanten. Ze kruisen ook met planten van het archeofytische type 1. Dit kan leiden tot zeer mooie mengvormen, zoals een zeer klein sneeuwklokje met intens groene punten en mooi opbollende buitenste bloembladeren dat we in februari 2008 in het Domein hebben aangetroffen (fig. 5).

Type 2: zaadvorming en ecologie

De verspreiding van het type 2 beperkt zich in het Domein van de Plantentuin tot de voormalige Engelse tuin rond het kasteel van Meise, en meer in het bijzonder de omgeving rond de oranjerie. Deze zone is zeer intens vergraven en werd genivelleerd ten tijde van de aanleg van de Engelse tuin door de Franse architect François Verly in 1818. Voordien was deze zone in gebruik als boomgaard en graasweide. Intensief begraasd grasland is niet meteen een geschikte omgeving voor sneeuwklokjes. De galantine in sneeuwklokjes is giftig en een bodem die regelmatig verdicht wordt door hoefdieren is niet ideaal.

Figuur 5. Een spontane hybride van planten van het type 1 en introducties uit de 19de eeuw. De mooie bolronde bloem en de geringe hoogte (amper 10 cm hoog) wijzen op type 1, terwijl de groene vlek op de buitenzijde van de bloemblaadjes verwijst naar in de 19de eeuw in het Domein geïntroduceerde cultuurvormen. Spontane variatie gevonden net buiten de Plantentuin, februari 2008.

Planten van het type 2 zijn in alle onderdelen een stuk forser en groter dan bij het type 1. Daarnaast is bij een temperatuur hoger dan 11°C ook de opvallende honinggeur duidelijk vanop een afstand te ruiken. De bloemen worden op dergelijke zonnige dagen opvallend druk bevlogen door bijen en hommels. De late bloei (eind februari en maart) garandeert bijna jaarlijks een goede bestuiving, wat resulteert in een rijke zaadvorming. Dergelijke planten hoeven minder energie te investeren in vegetatieve boldeling en polvorming.

Binnen het Domein van de Plantentuin beschouwen we het type 2 als een stinsenplant. Gelijkaardige sneeuwklokjes met rijke zaadvorming komen ook voor in andere Engelse tuinen die door F. Verly werden aangelegd (eigen waarnemingen). Waarschijnlijk werden deze sneeuwklokjes door de ontwerper bewust uitgekozen omdat ze beduidend groter zijn dan de planten van het type 1. Ook kan de zoete honinggeur hebben meegespeeld bij de keuze van dit type sneeuwklokjes voor de Engelse tuin.

Prospectie op verschillende reeds in het verleden vermelde vindplaatsen wijst uit dat dit type sneeuwklokjes massaal voorkomt langs wegkanten, in droge gemengde hakhoutbestanden en in taluds van holle wegen in de grensstreek tussen Brabant, Henegouwen en Oost-Vlaanderen, en op het Brabantse leemplateau ten westen van Brussel. Het is precies ook op wandtapijten afkomstig van kunstcentra binnen deze zones dat de oudste afbeeldingen van sneeuwklokjes worden aangetroffen (eigen waarneming).

De talrijke en verspreide aanwezigheid en de duidelijke weergave van sneeuwklokjes in kunstwerken vanaf de late 14de eeuw suggereert dat het type 2 inheems zou kunnen zijn op het Brabantse leemplateau tussen Doornik en Halle.

Besluit

Recent onderzoek in de Plantentuin en elders in België leidt ons tot de conclusie dat in de Plantentuin het onder hakhout groeiende sneeuwklokje van wat wij type 1 hebben genoemd een archeofyt is. De precieze verspreiding ervan in het Domein weerspiegelt het historisch beheer van de hakhoutbestanden door de mens. Door het wegvallen van dit beheer gaat type 1 in dit oorspronkelijk habitat in de Plantentuin momenteel achteruit. Het weet zich echter te handhaven – en breidt zich zelfs uit – in de rand van diverse parkboszones waar het in de 19de eeuw werd aangeplant.

In de zones binnen de vroegere kasteeldomeinen waar type 1 werd uitgeplant, werden in de 19de eeuw ook andere bollen geïntroduceerd, vermoedelijk afkomstig uit Duitsland. Deze bollen produceren bloemen met groene punten en zijn te beschouwen als stinsenplanten. In de buurt van de zuivere vormen komen ook hybriden voor. Wel dient aangestipt dat populaties van vermoedelijk Duitse herkomst tot nu toe enkel zijn aangetroffen in restzones van het voormalige park die vandaag buiten de omheining van de huidige Plantentuin liggen.

De forsere planten van wat wij als type 2 hebben beschreven, kunnen we beschouwen als een in België inheems sneeuwklokje dat in de vroege 19de eeuw in het Domein werd

geïntroduceerd tijdens de tuinaanleg rond het kasteel van Meise. Binnen de Plantentuin is dit type dus eveneens te beschouwen als een door de mens geïntroduceerde stinsenplant.

In een ruimere West-Europese context kan men stellen dat, net zoals *Primula vulgaris* in West-Vlaanderen, het natuurlijke verspreidingsareaal van *Galanthus nivalis* vermoedelijk doorloopt tot op Belgisch grondgebied, namelijk tot op het Brabantse leemplateau tussen Cambrai en Brussel. Buiten dit beperkte gebied moet *G. nivalis* in België beschouwd worden als een archeofyt, een stinsenplant of op zijn hoogst als een plaatsen waar ze recent als 'in het wild' groeiende plant is aangetroffen als een verwilderde tuinplant.

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Literatuur

Crépin F. (1860) – Manuel de la flore de Belgique. Bruxelles, Emile Tarlier [+ latere edities: 1866, ed. 2, Bruxelles, G. Mayolez; 1874, ed. 3, Bruxelles, G. Mayolez; 1882, ed. 4, Bruxelles, G. Mayolez; 1884, ed. 5, Bruxelles, G. Mayolez.]

Daems F. & Slembrouck J. (1991) – Het sneeuwklokje (Galanthus nivalis L.) in de omgeving van Antwerpen, de huidige situatie. *Dumortiera* **47**: 6-8.

Davis A.P. (1999) – The genus Galanthus. Portland, Timber Press, in association with the Royal Botanical Gardens, Kew.

De Langhe J.-E. (1991) – Het sneeuwklokje (Galanthus nivalis L.) in de omgeving van Antwerpen, een halve eeuw geleden. *Dumortiera* **47**: 2-5.

De Langhe J.-E. *et al.* (1967) – Flore de la Belgique, du nord de la France et des regions voisines. Liege, Editions Desoer.

De Langhe J.-E. *et al.* (1973) – Nouvelle flore de la Belgique, du Grand-Duche de Luxembourg, du Nord de la France et des regions voisines. Bruxelles, Jardin botanique national de Belgique [+ latere edities: 1978, ed. 2 (De Langhe *et al.*), Meise, Jardin bot. nat. Belgique; 1983, ed. 3 (De Langhe *et al.*), Meise, Jardin bot. nat. Belgique; 1992, ed. 4 (Lambinon *et al.*), Meise, Jardin bot. nat. Belgique; 2004, ed. 5 (Lambinon *et al.*), Meise, Jardin bot. nat. Belgique.]

Goffart J. (1934) – Nouveau manuel de la flore de Belgique et des regions limitrophes. Liege, Editions Desoer [+ latere edities: 1941, ed. 2, Liege, Desoer; 1945, ed. 3, Liege, Desoer.]

Ronse A. & Leten M. (2011) – Wood lawn neophytes: historical park relics. *Scripta Bot. Belg.* **47**: ***-***.

Tack G., Van den Bremt P. & Hermy M. (1993) – Bossen van Vlaanderen, een historische ecologie. Leuven, Davidsfonds.

Van den Bremt P. (2006) – Galanthus nivalis: sneeuwklokje. *In* Van Landuyt W. *et al.* – Atlas van de flora van Vlaanderen en het Brussels Gewest: 418-419. Brussel & Meise, INBO, Nationale Plantentuin van België & FLORON.

von Gottlieb-Tannenhain P. (1904) – Studien über die Formen der Gattung Galanthus. Abhandlungen der K.K. Zool.-Botan. Gesellschaft in Wien, Band II, Heft 4. Wien, A. Holder.

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Observations on the occurrence of *Cirsium ×hybridum* in Belgium

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Scripta Bot. Belg. **47**: I. Hoste (ed.), The spontaneous flora of the National Botanic Garden of Belgium (Domein van Bouchout, Meise)

Résumé. – Quelques notes sur la présence de *Cirsium ×hybridum* en Belgique. *Cirsium ×hybridum* Koch ex DC. (*C. palustre* × *C. oleraceum*), rare en Belgique, a récemment été observé dans le Domaine du Jardin botanique national de Belgique à Meise. Cela a permis l'etude de cet hybride *in vivo*. Les collections belges provenant de différents herbiers ont également permis l'etude de son développement et de sa fertilité. Les résultats suggèrent que les populations peuvent se maintenir comme hémicryptophyte, par la production répétée de graines ou par de nouveaux hybrides entre les deux parents. Les deux parents étant largement distribués, l'hybride reste neanmoins rare, ce qui indique que les mécanismes menant a l'hybridation sont peu efficaces.

Samenvatting. – Notities bij het voorkomen van *Cirsium ×hybridum* in België. De zeldzame hybride *Cirsium ×hybridum* Koch ex DC. (*C. palustre* × *C. oleraceum*) werd recent waargenomen in het Domein van de Nationale Plantentuin van België in Meise. Dit bood kansen om de hybride *in vivo* te bestuderen. De levenscyclus en fertiliteit van *C. ×hybridum* werden verder onderzocht aan de hand van Belgische herbariumcollecties. De resultaten suggereren dat populaties jarenlang kunnen overleven als overblijvende planten, of ook wel door zaadzetting of herhaald optredende kruisingen tussen de beide ouders. Het algemeen verspreid voorkomen van de ouders en de zeldzaamheid van de hybride wijzen er echter op dat die mechanismen weinig efficient zijn.

Introduction

In 2007, a single flowering plant of *Cirsium ×hybridum* (*C. palustre* × *C. oleraceum*) was discovered in the grounds of the National Botanic Garden of Belgium, Meise. A second plant flowered in 2008. As only the second recorded site of this hybrid from Belgium for half a century, it presented a rare opportunity to make observations and study this hybrid at close hand.

Both parents grow spontaneously in semi-wild areas of the garden that are managed for wild plants. *Cirsium palustre* is found mainly in damp turf that is mown several times a year and heavily grazed by geese. *Cirsium oleraceum* grows next to the lakes and streams in tall herbaceous vegetation, cut once a year.

Cirsium palustre is monocarpic and under good conditions flowers in its second year (Ramula 2008). *Cirsium oleraceum* on the other hand is a perennial. It has not been reported in the literature whether *C. ×hybridum* is monocarpic or perennial. Both parents flower for a long period starting in mid-June, but with their main flowering period in July and August. Both have a diploid chromosome number of 34.

Cirsium ×hybridum is a distinctive plant, with most characteristics intermediate between its parents. In overall shape it is most similar to *C. palustre*, with long internodes, spiny leaves and spiny wings down the stem. It also lacks the pale green bracts of *C. oleraceum*. Unlike *C. palustre*, however, it has large creamy white coloured capitula.

The Belgian herbarium of the National Botanic Garden of Belgium and the Herbarium Universitatis Leodiensis (Liège) contain 45 and 7 specimens of *C.* ×*hybridum*, respectively. The specimens from Berg (Vlaams-Brabant) are notable because the first specimen was collected in 1861 and the hybrid is still known at this site. In 2008, only one plant was found at the Torfbroek nature reserve in Berg, but the manager of the site reports that the number of flowering plants fluctuates from year to year (Jan Wouters, personal communication). The numerous herbarium specimens from places such as Virton, Tienen and Loupoigne also show that the hybrid can persist at a site for many years, though the number of plants at these sites is unrecorded. At least, in the case of a specimen from Vance, it is mentioned that more than one plant of the hybrid was simultaneously present.

How then, are hybrid plants maintained over many years? Are the hybrids frequently produced from their parent species? Are the hybrids perennial, or do they produce viable seeds and create a self-sustaining hybrid population?

Methods

All the Belgian herbarium specimens of the National Botanic Garden of Belgium (BR) and the Herbarium Universitatis Leodiensis (LG) were examined in this study. No records of *Cirsium* ×*hybridum* are present within the databases of either INBO (www.inbo.be) or the Faculté universitaire des Sciences agronomiques de Gembloux (biodiversite.wallonie.be).

The full details of the BR specimens are available on the website of the garden (www.br.fgov.be). All the Belgian specimens from LG were duplicates of specimens already held at BR so further examination was restricted to those held at BR.

The BR specimens are identified by the following barcode numbers: BR0000011688952, BR0000012455393, BR0000011137108, BR0000011689195, BR0000011689522, BR0000012317707, BR0000012232598, BR0000011688297, BR0000012317721, BR0000011689218, BR0000011689249, BR0000011688914, BR0000011688709, BR0000011688778, BR0000011688839, BR0000011689133, BR0000011688556, BR0000011689348, BR0000011689010, BR0000011688358, BR0000011688372, BR0000011688686, BR0000011688730, BR0000011689379, BR0000011688624, BR0000011689041, BR0000011688716, BR0000011688389, BR0000011689409, BR0000011689430, BR0000011689393, BR0000011688747, BR0000011689102, BR0000012449965, BR0000012450060, BR0000011688419, BR0000012232574, BR0000012232581, BR0000012232567, BR0000011689072, BR0000011688327, BR0000011688440, BR0000012507351, BR0000011689577, BR0000012449866.

The identity of each specimen was confirmed and the capitula were examined to see if seeds and pollen were present. However, as these are valuable specimens, they were not dissected.

Pollen viability for the specimen found at Meise in 2007 was assessed using acetocarmine staining.

Results

• Life history

Cirsium ×*hybridum* at Meise is perennial, but it does not flower every year. After flowering the whole rosette dies back and only weakly reappears from the rootstock the following year. As in most of its characteristics this is an intermediate situation to its parents. Mature *C. oleraceum* will flower every year and *C. palustre* dies after flowering.

• Proximity to parents and to other hybrids

Cirsium ×*hybridum* is often found with both parents and close to other specimens of the hybrid. The proximity to both parents is evident from notes on several herbarium sheets (BR0000012317707, BR0000011688419, BR0000012232574, and BR0000012232581, from the literature (Stöhr 2006, Wesmael 1860), and from observations at the Botanic Garden and at the Torfbroek nature reserve in Berg.

Hybrid plants are often found close to one another. Both plants of *Cirsium* ×*hybridum* at the Botanic Garden grow in the same habitat as *C. oleraceum*, only 1 m apart from each other and within 3 m of both parents. Given there is more than 200 m² of habitat in the garden where *C. oleraceum* and *C. palustre* grow together then the chance of them growing within 1 m of each other by chance is less than 1 %.

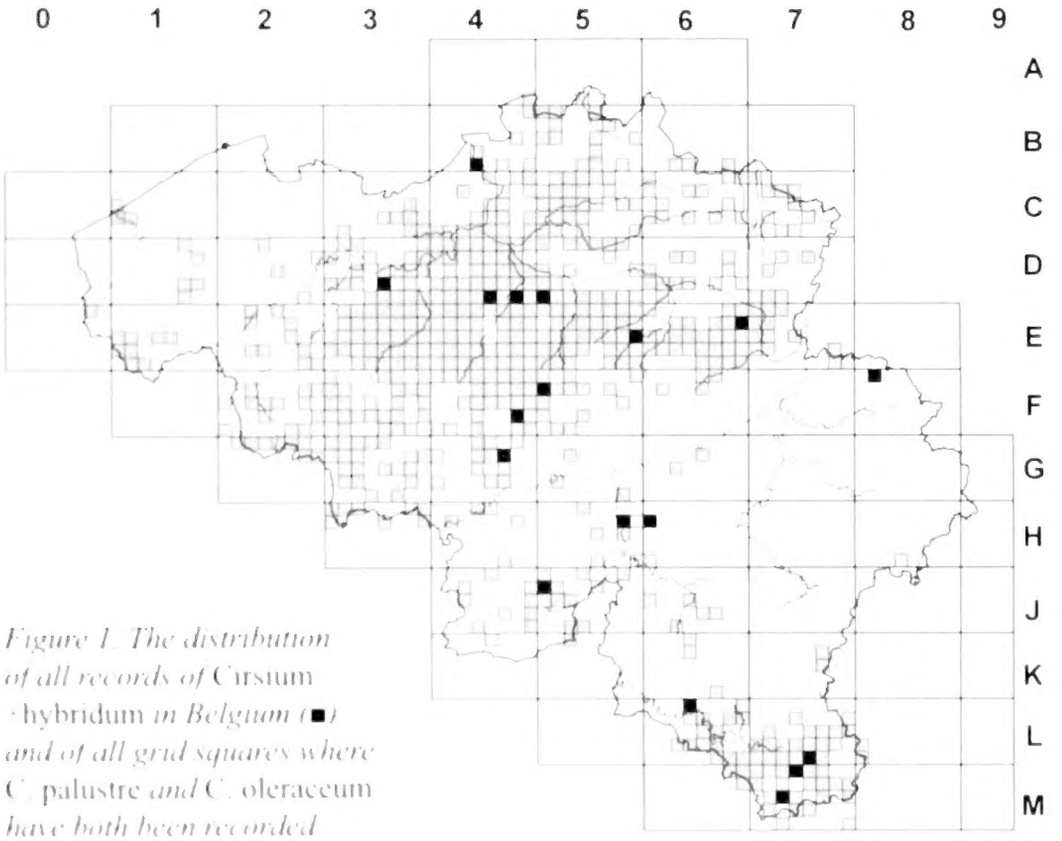

Figure 1. The distribution of all records of Cirsium ×hybridum *in Belgium (■) and of all grid squares where* C. palustre *and* C. oleraceum *have both been recorded.*

The 45 specimens in the Botanic Garden's herbarium and the specimens from the University of Liège, were collected from only 18 localities, on dates between 1824 and 2007. Though more specimens were collected in the 19th century (26), specimens from the 20th and 21st centuries were from more localities (11). Figure 1 shows the distribution of *C. ×hybridum* in Belgium. Clearly, the hybrid is found close to areas where both parents are also found. Since *C. palustre* is practically ubiquitous within Belgium the occurrence of *C. ×hybridum* is related more with the distribution of *C. oleraceum*.

• Fertility and sexuality

To investigate the fertility of the hybrid, open-pollinated seed heads were collected and dissected. From 30 seed heads 49 seeds were collected. The maximum number of seeds found in any one capitulum was three. Seven seeds were germinated after cold storage and all proved to be viable. At least six herbarium specimens had fully formed seed, though this number may be greater, as specimens were not systematically dissected.

Two *C. ×hybridum* plants where grown to maturity from the seeds collected from the wild plants in the garden. Their floral and vegetative characters were the same as the hybrid parent.

The number of seeds per capitulum is low in comparison with the number of florets. Furthermore, *C. palustre* is recorded as having as many as 30 seeds per flower head (van Leeuwen 1981). Though, the true fertility of *C. ×hybridum* may be slightly greater as the seed heads are occasionally infested with the Thistle-head weevil (*Rhinocyllus conicus*). Greater than 90 % of the pollen grains from one plant at the Botanic Garden stained with acetocarmine, indicating that it is potentially viable.

Both *C. palustre* and *C. oleraceum* are gynodioecious (Delannay 1979). Therefore, hybrids might be expected to be either functionally female or hermaphrodite. Hermaphrodite flowers have long anthers usually reaching or exceeding the corolla lobes. Female flowers have shorter anthers not containing pollen. Both living specimens, growing in the garden were hermaphrodites, while 35 of 42 assessed herbarium specimens were hermaphrodites, the others being male sterile.

Although hermaphrodite plants appear more common there may be several biases in the specimens. These biases include, different

herbarium sheets having been collected from the same plant and single sheets containing material from more than one plant.

Discussion

Although, *C. ×hybridum* has been observed to perennate, this cannot explain why small populations of this hybrid are occasionally found. *Cirsium ×hybridum* does not have a mechanism of vegetative reproduction so populations of the hybrid are either being created *de novo* from the parents or from seed from the hybrid plants.

If the hybrid persisted through self-pollination or backcrossing with either parent then segregation of the parent alleles would be expected. The normal hybrid's flower colour (white with lilac anthers) resembles the intermediate colour polymorphism described by Mogford (1974) that occurs naturally in populations of *C. palustre* in the United Kingdom. In *C. palustre* the white and purple alleles are co-dominant and the intermediate colour polymorphism is presumably heterozygous (Mogford, 1974). Therefore, the F2 progeny of selfed plants that inherit both purple alleles from *C. ×hybridum* might be expected to have purple flowers. Likewise, some plants from a backcross to *C. palustre* might also have purple flowers. Yet, *C. ×hybridum* is usually only ever found with white flowers. The sole exception is one herbarium specimen of a single plant from Vance which was collected because it had purple flowers (D'Ansembourg, s.n., 1949, BR0000012317721). The notes on this specimen make it clear that this was exceptional amongst other hybrid plants at the same site. None of the literature descriptions of *C. ×hybridum* has described a purple corolla (Stöhr 2006, Wesmael 1860). Nor is there evidence from the literature that backcrossing of the hybrid occurs with the parents, even though the hybrid is either frequently or mostly found with both parents. Furthermore, morphologically the hybrid and parents are quite distinct and there is no morphological evidence of introgression.

A lack of backcrossing and or segregation of alleles might be due to apospory. Though there is plenty of evidence for sexual reproduction in these *Cirsium* species (Mogford 1974); both *C. palustre* and *C. oleraceum* are reported to be aposporus (Czapik & Kosciński-Pająk 2000). This would explain the production of seed by *C. ×hybridum*, without segregation of alleles. In this case, once rare hybrid plants are formed from the parents, the population can grow clonally through apomixis. Given the general lack of introgression, the production of fertile seeds; the clustering of hybrid plants and the apparent rarity of the hybrid in comparison with the parents, the apomictic perpetuation of *C. ×hybridum* is an attractive hypothesis. Nevertheless, the evidence for apomixis in *Cirsium* has been questioned and requires further investigation (Noyes 2007).

In conclusion, it appears that *C. ×hybridum* can persist through perennation, through seed production from the hybrid and from *de novo* creation of the hybrid from the parents. Yet none of these mechanisms appears particularly efficient and there is no evidence that the hybrid could significantly compete with one or either of its parents.

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References

Czapik R. & Kosciński-Pająk M. (2000). Apomictic studies and agamospermy in Polish flora. *Polish Bot. Stud. Guidel. Ser.* **24**: 129–140.

Delannay X. (1979). Evolution of male sterility mechanisms in gynodioecious and dioecious species of Cirsium (Cynareae, Compositae). *Plant Syst. & Evol.* **132 (4)**: 327–332.

Mogford D. J. (1974). Flower-colour polymorphism in Cirsium palustre L. *Heredity* **33**: 241–256.

Noyes, R.D. (2007). Apomixis in the Asteraceae: diamonds in the rough. *Functional Plant Science and Biotechnology* **1**: 207–222.

Ramula S. (2008) – Population dynamics of a monocarpic thistle: simulated effects of reproductive timing and grazing of flowering plants. *Acta Oecologica* **33 (2)**: 231-239.

Stöhr O. (2006) – Cirsium Hybriden im Bundesland Salzburg. *Linzener Biologische Beitrage* **38(1)**: 189-216.

van Leeuwen B.H. (1981) – The Role of Pollination in the Population Biology of the Monocarpic Species Cirsium palustre and Cirsium vulgare. *Oecologia* **51**: 28-32.

Wesmael M.A. (1860) – Une Hybride de Cirsium. *Bulletins de l'Académie Royale des Sciences*, 2nd series **10**.

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The vegetation of the enclosed courtyard at the herbarium building

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Scripta Bot. Belg. **47**: I. Hoste (ed.), The spontaneous flora of the National Botanic Garden of Belgium (Domein van Bouchout, Meise)

Résumé. La végétation spontanée de la cour interne de l'herbarium du Jardin botanique national de Belgique. Depuis deux décennies une végétation variée, issue d'une série d'introductions spontanées de plantes venant de l'extérieur, s'est développée dans une cour entièrement entourée par le bâtiment d'herbier. L'évolution et l'état actuel de la végétation sont brièvement décrits. La plupart des propagules ont été apportées par le vent et les oiseaux. Pendant la phase initiale de la colonisation de la cour, le vent était le vecteur dominant, mais depuis le contingent de plantes introduites par des oiseaux a sensiblement augmenté.

Samenvatting. De spontane begroeiing van de binnenkoer van het herbariumgebouw van de Nationale Plantentuin van België. Sinds twee decennia heeft zich op de ingesloten binnenkoer van het herbariumgebouw een vegetatie ontwikkeld van uitsluitend spontaan van buitenaf aangevoerde plantensoorten. De ontwikkeling en de huidige toestand van de begroeiing worden beknopt beschreven. De meeste propagulen werden aangevoerd door wind en vogels. Tijdens de vroegste kolonisatiefase voerde vooral de wind zaden aan, maar inmiddels is het aandeel van door vogels aangevoerde soorten sterk toegenomen.

Introduction

The construction of the new herbarium building of the National Botanic Garden in Meise (1953-1959) created a triangular central courtyard enclosed by the three wings of the building. Initially the whole building rested on columns that support the two or four stories that house the herbarium and library facilities, with at the ground level an open gallery. This gallery connected the central courtyard with the garden around the building. In the 1980s, however, the gallery was enclosed, thereby completely isolating the central courtyard from the surrounding area.

The courtyard measures about 7,000 m², including a central pond with vertical sidewalls of about 3,500 m² (Fig. 1). An overflow prevents this basin from flooding the pavement during periods of heavy rain. In 1978 a varied collection of aquatic plants was introduced into the pond (Van de Vijver & Compère 2011); some of these have prospered over the years, but others have disappeared.

The whole border area around the pond was paved. In the early years the pavement was intensively maintained. No terrestrial plants or

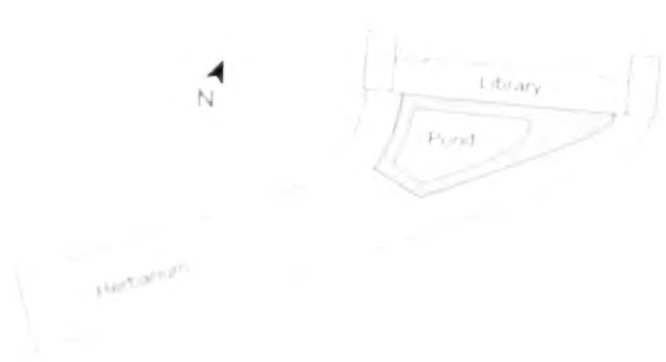

Figure 1. Plan of the herbarium building showing the pond surrounded by the courtyard pavement (grey zone).

Figure 2. The central courtyard of the herbarium building in 1978. Until the early 1980s an open gallery connected the courtyard with the rest of the Domain of the National Botanic Garden, thereby potentially facilitating the spontaneous introduction of seeds into the courtyard. Not a single weedy species was, however, tolerated in the gaps between the paving stones. (Photo L. Vanhecke)

Figure 3. This photograph from 1984 shows the then recently enclosed courtyard. From 1978 a collection of aquatic plants had been introduced in the central basin, but intensive weed management prevented plants from colonizing the pavement. (Photo L. Vanhecke)

plant boxes were introduced. The gardener responsible for this little corner of the Botanic Garden tolerated not a single weedy species in the gaps between the paving stones. This labour-intensive management was abandoned in the early 1990s. In the almost two decades since there has been very little intervention with the spontaneous colonization of the pavement by a diversified range of plant species (Fig. 2-6). In the early years young plants emerged in the gaps and soon a thin layer of humus started to build up. Geerinck (1997) was the first to make an inventory list of the terrestrial plants of the courtyard. A decade later a second inventory has been made. Most data is from 2007 and 2008, with some minor additions from 2009 and 2010. Geerinck ignored the plants of the pond and therefore water plants have been omitted from this publication too.

A spontaneous vegetation

Once an area has been abandoned, it doesn't take long before the first colonizing plants, both indigenous and alien, arrive and prosper. The first arrivals that dominate the vegetation are annuals or biennials, before long followed by perennials, shrubs and trees, including *Acer pseudoplatanus*, *Betula pendula*, *Fraxinus excelsior* and several different species of genus *Salix*.

Figure 4. Intensive weed management was abandoned in the early 1990s. By 2011 dense woody vegetation has spontaneously developed on the pavement. Hot and dry conditions on the north side of the pond (along the building that houses the library) have locally hampered the growth of trees and shrubs when compared to the more shaded and cooler parts of the courtyard. (Photo L. Vanhecke)

Figure 5. In 2011 the vegetation of the courtyard is dominated by willows (Salix)*, especially goat willow* (S. caprea)*. Two decades after the abandonment of active weed management, five self-sown trees have attained a diameter of over 25 cm at 1 m above the ground (with a single tree reaching 33 cm). (Photo L. Vanhecke)*

Figure 6. Whereas the previous pictures (fig. 4 and 5) were taken in February 2011, this one is from early October 2011. When in leaf, the visual effect of the trees is much more pronounced than in winter. The central water basin is almost completely hidden from sight. (Photo S. Bellanger)

Due to the pavement, colonization of the courtyard was not obvious. Still, plants soon sprouted from the cracks between the paving stones. Decaying plant material, mixed with dust, soon created a thin layer in which seeds and spores could germinate. From a seemingly very uniform and inhospitable substrate, the pavement around the pond evolved into a remarkably rich and spatially varied plant community. The spatial variation is largely due to varying amounts of sunshine reaching the different parts of the courtyard. During the summer, part of the area along the north side of the basin is hot and dry in periods of sunny weather. Especially during periods of continuous drought, mortality can be high among the young shrubs and trees. This explains the less luxuriant state of the vegetation in this zone of the courtyard. On the other hand, this is precisely the zone where drought tolerant species such as *Lavandula angustifolia* and *Senecio inaequidens* thrive. It is also in this less shaded area that *Veronica arvensis*, *Cerastium glomeratum*, *Hieracium lachenalii* and a few poorly developed specimens of *Trifolium repens* prefer to grow.

Elsewhere the vegetation is denser and the trees grow higher, easily reaching or, especially in the case of some willows, overtopping the surrounding herbarium building. *Buddleja davidii*, which was among the first and most striking colonisers, is today increasingly getting outcompeted by other species, predominantly *Salix caprea*. Under the trees, the vegetation of the more permanently shaded parts is fairly uniform. Young woody plants, including numerous *Taxus baccata*, sprout everywhere, most of them without the prospect of a long life. On the south side of the basin the vegetation is locally dominated by *Fragaria vesca* and *Plagiomnium undulatum*. The most remarkable indigenous species recorded so far is *Asplenium adiantum-nigrum*, very rare in Flanders but with a small population (7 plants in 2010) on the border of the pond. *Geranium robertianum* and *Hedera helix* are very well represented in the ground cover vegetation in the eastern zone.

The 2007-2010 inventory contains a relatively large number of non-indigenous plant species. Some of these are today spreading in large parts of Western Europe, see e.g. *Buddleja davidii* and *Senecio inaequidens*. Others, such as *Lunaria annua*, are often recorded as garden escapes. Due to the presence in the Domain of a large collection of living plants from all over the world, the list of non-indigenous plants in the herbarium building courtyard also contains quite a few rarities. These include not only several different species of *Cotoneaster* (a genus popular with garden and park managers), but also some poplars that prove hard to identify with certainty. *Populus deltoides*, one of the parents of *P.* ×*canadensis*, was mentioned by Geerinck (1997), who also made a herbarium collection, but today this tree seems to have disappeared. As local escapes from the living collections valued by horticulturists for their attractive flowers we can mention *Deutzia scabra* (flowering each year in the courtyard), *Lonicera nitida* (cultivated in the close vicinity of the herbarium building), *Lonicera* ×*purpusii* and *Spiraea japonica* var. *acuminata*.

Origin of the introduced plant species

Lying as it does, isolated from the rest of the Domain, the courtyard has become an interesting small "experimental garden", offering opportunities to study the processes of colonization and succession. Due to a lack of monitoring over the past two decades, the existing data only represents two snapshots that illustrate a highly dynamic colonization process. A few general conclusions can, however, be drawn from this data. As compared with Geerinck (1997) the proportion of pioneer species* has diminished, while the total number of species has strongly increased: thirteen taxa mentioned in 1997 have since disappeared, whereas 65 new taxa have been added to the list during the period 2007-2010 (Table 2).

Numerous plant species depend on more than one strategy for propagule dispersal. In

* Although Geerinck (1997) mentions *Cardaria draba*, this name has here been replaced with the more plausible *L. serrulata*.

table 2, however, we have restricted our information to a single dispersal vector for each plant species, namely the one that is suspected to have been decisive in bringing propagules into the isolated herbarium building courtyard. In so doing we have discounted other potential vectors, such as transportation of seeds by flowing water or – perhaps not completely irrelevant? – transportation by ants.

Two vectors are responsible for the introduction of the large majority of plant species in the courtyard. Numerous grains, fruits and spores are transported by strong winds (anemochory), others are introduced by birds that feed on fruits or seeds, and that afterwards visit the courtyard while looking for food, shelter, or a place to build their nest (ornithochory). 47 % of the taxa recorded in 2007-2010 belong to the first, and 34 % to the second category (Table 1). Due to the height of the surrounding walls, semachorous species – which are dispersed by wind in the immediate vicinity of the mother plant only – have not been withheld as 'anemochorous' in the species list.

In the early years wind dispersal was the main source for newcomers in the courtyard. Apart from the well-vegetated pond, birds found little to attract them to the paved area, which offered little or no food and shelter. All this changed once young trees and shrubs had managed to get a foothold in the pavement joints. This explains why in the early years the proportion of species introduced by wind outnumbered those introduced by birds.

For a number of plant species (19 % of all those recorded in 2007-2010) it is not clear how they reached the courtyard. Occasionally a gust of wind may have blown rather heavy seeds or fruits over the high barrier of the surrounding walls during stormy weather, or a bird may exceptionally have brought in propagules sticking to its feathers or feet. A single plant of *Carex pendula* growing on the pavement probably descends from cultivated plants in the pond (although these plants have now disappeared), or it may have been introduced by a bird. *Cardamine hirsuta* and *C. flexuosa* (two weedy species that catapult away their seeds from the ripe pods), and also *Erigeron karvinskianus* (a cultivated plant that produces wind-borne achenes), almost certainly originated from plants growing in flower boxes on the terrace at the fourth floor of the herbarium building.

Geranium robertianum f. *laciniatum*

Amongst the numerous plants of *Geranium robertianum* growing in the courtyard one can sometimes spot specimens with anomalous leaves. All or just a few of the leaves of this form *laciniatum* Beckhaus (Lawalrée 1964) are characterized by lanceolate and deeply laciniated primary divisions (fig. 7). In the Domain this form has also been recorded from the immediate vicinity of the herbarium building. In the central courtyard it was recorded in 2007 and 2010. In 2011 it has also been spotted in the vicinity of the herbetum (sector 54; pers. comm. A. Ronse).

Such unusual plants have little taxonomic significance, and have received little attention from field botanists. It is hard to tell whether they are really rare; they have probably often been overlooked. In the collections of the

Table 1. Plant species recorded from the courtyard of the herbarium divided in three categories: anemochorous plants, ornithochorous plants, and 'rest group' (including species with an unknown dispersal mechanism).

	Anemochorous		Ornithochorous		Other and unknown		Total	
	n	%	n	%	n	%	n	%
Recorded in 1997	26	**79**	4	**12**	3	**9**	33	**100**
Recorded in 1997 and/or 2007-2010	50	**51**	32	**33**	16	**16**	98	**100**
Recorded in 2007-2010	40	**47**	29	**34**	16	**19**	85	**100**

Taxon	Status	Dispersal	Period(s)
Acer platanoides	Ind	Ane	2
Acer pseudoplatanus	Ind	Ane	1+2
Acer pseudoplatanus f. purpurascens	Ind	Ane	2
Agrostis gigantea	Ind	Orni	1
Asplenium adiantum-nigrum	Ind	Ane	2
Asplenium scolopendrium	Ind	Ane	2
Asplenium trichomanes	Ind	Ane	2
Betula jacquemontii	Cult	Ane	2
Betula pendula	Ind	Ane	1+2
Betula pubescens	Ind	Ane	2
Betula x rhombifolia	Ind	Ane	1+2
Brachypodium sylvaticum	Ind	Ane	2
Buddleja davidii	Cult/Nat	Ane	1+2
Calamagrostis epigejos	Ind	Orni	2
Cardamine flexuosa	Ind	?	2
Cardamine hirsuta	Ind	?	2
Cardamine pratensis	Ind	?	2
Carex pendula	Ind	?	2
Carpinus betulus	Ind	Ane	2
Cerastium fontanum	Ind	?	2
Cerastium glomeratum	Ind	?	2
Cirsium arvense	Ind	Ane	1+2
Cirsium oleraceum	Ind	Ane	2
Cirsium vulgare	Ind	Ane	2
Conyza canadensis	Nat	Ane	1
Cotoneaster bullatus	Cult	Orni	2
Cotoneaster divaricatus	Cult	Orni	2
Cotoneaster franchetii	Cult	Orni	2
Cotoneaster salicifolius var. floccosus	Cult	Orni	2
Crataegus monogyna	Ind	Orni	2
Deutzia scabra	Cult	?	1+2
Dryopteris filix-mas	Ind	Ane	2
Elaeagnus umbellata	Cult	Orni	1
Epilobium angustifolium	Ind	Ane	2
Epilobium montanum	Ind	Ane	1+2
Epilobium parviflorum	Ind	Ane	1+2
Epipactis helleborine	Ind	Ane	2
Erigeron karvinskianus	Cult	Ane	2
Eupatorium cannabinum	Ind	Ane	1+2
Festuca arundinacea var. aspera	Ind	Orni	1
Fragaria vesca	Ind	Orni	2
Fraxinus excelsior	Ind	Ane	1+2
Fraxinus ornus	Cult	Ane	2
Galinsoga ciliata	Ind	Ane	2
Geranium robertianum	Ind	?	1+2
Geum urbanum	Ind	Orni	2
Gnaphalium luteoalbum	Ind	Ane	1
Hedera helix	Ind	Orni	2
Hieracium lachenalii	Ind	Ane	2
Holcus lanatus	Ind	Orni	1+2
Hypericum perforatum	Ind	?	2
Ilex aquifolium	Ind	Orni	2
Juncus effusus	Ind	?	2
Lactuca serriola	Ind	Ane	1

Table 2. Plant species recorded from the courtyard of the herbarium building of the National Botanic Garden of Belgium in 1997 and 2007-2010.

Legend:

Status: status in Belgium (**Ind:** indigenous, **Nat:** naturalized, **Cult:** cultivated)

Dispersal: dispersal mechanism that best explains the introduction of a plant species in the courtyard (**Ane:** anemochory, **Orni:** ornithochory, **?:** other mechanism or mechanism unknown, almost certainly not anemochory or ornithochory)

Period(s): recorded during the first (**1**), second (**2**) or both (**1+2**) surveys

For the indigenous species the dispersal mechanism is based on Flora Databank (http://flora.nbgb.be/Pages/Common/Default.aspx)

Lavandula angustifolia	Cult	?	2
Leontodon autumnalis	Ind	Ane	1
Lonicera nitida	Cult	Orni	2
Lonicera x purpusii	Cult	Orni	2
Lunaria annua	Cult/Nat	?	2
Mahonia aquifolium	Cult/Nat	Orni	2
Malus sieboldii	Cult	Orni	2
Picris hieracioides	Ind	Ane	1+2
Pinus strobus	Cult	Ane	2
Pinus sylvestris	Ind?	Ane	2
Poa annua	Ind	Orni	2
Poa nemoralis	Ind	Orni	2
Populus deltoides	Cult	Ane	1
Populus nigra	Cult *	Ane	1+2
Populus nigra var. betulifolia	Cult	Ane	2
Populus x canadensis	Cult	Ane	1
Populus x *generosa* (*P. deltoides* x trichocarpa)	Cult	Ane	1
Prunella vulgaris	Ind	?	2
Prunus avium	Ind	Orni	2
Pulicaria dysenterica	Ind	Ane	1
Ribes uva-crispa	Ind	Orni	2
Rosa spec	Cult	Orni	2
Rubus caesius	Ind	Orni	2
Salix alba	Ind	Ane	1+2
Salix caprea	Ind	Ane	1+2
Salix cf. x sericans	Ind	Ane	1
Salix cinerea s.l. **	Ind	Ane	1
Salix x rubens ***	Ind	Ane	1+2
Sambucus nigra	Ind	Orni	2
Sambucus nigra var. laciniata	ind	Orni	2
Senecio inaequidens	Nat	Ane	2
Silene dioica	Ind	?	2
Sorbus aucuparia	Ind	Orni	2
Spiraea japonica var. acuminata	Cult	?	1+2
Taraxacum officinale	Ind	Ane	1+2
Taxus baccata	Ind	Orni	2
Tilia platyphyllos	Ind	Ane	2
Trifolium repens	Ind	Orni	2
Tussilago farfara	Ind	Ane	1+2
Ulmus glabra	Ind	Ane	2
Veronica arvensis	Ind	Orni	2
Veronica chamaedrys	Ind	Orni	2
Viburnum spec.	Cult	Orni	2
Viola riviniana	Ind	?	2

* Var. *nigra*: indigenous, yet very rare in Belgium.
** Including *Salix atrocinerea*, *S. multinervis* and *S. aquatica*.
*** Including *Salix fragilis*.

National Botanic Garden herbarium (BR) we identified at least two specimens of *Geranium robertianum* f. *laciniatum* from Belgium. The first one is from the citadel of Namur (two sheets, *Jh. Legrain*, 1952), the second one from Comblain-au-Pont (N. *Crop*, 1954). We also found a few collections in which the leaves are intermediate between the normal form and f. *laciniatum*, testifying to the variability of leaf shape in *G. robertianum*.

Figure 7. Geranium robertianum *f.* laciniatum. *Two leaves from a specimen collected at the courtyard, May 2010. 'Typical' and intermediate leaves coexist on the same plant. (Drawing Sven Bellanger)*

Bryophytes

In the Spring of 2010 an inventory was made of the mosses growing in the enclosed courtyard of the herbarium building. In 1989, at the occasion of a Europalia Japan exhibition at the Botanic Garden, a temporary moss garden was laid out on the pavement, but no obvious remnants of the usually acidophilic moss species introduced then have been recorded in 2010.

In the shaded zones, where the pavement is covered with a layer of dead leaves and twigs, extensive moss carpets cover the soil. Here pleurocarps are dominant, especially *Plagiomnium undulatum*. In the same shaded zones several different epiphytes (including *Frullania dilatata*, *Metzgeria furcata* and *Radula complanata*) can be found growing on the trunks and branches of trees and shrubs (especially *Salix* and *Buddleja davidii*).

Parallel with the spatial variation in the vegetation of phanerogams, the moss vegetation from the dryer zone situated along the northern wing of the herbarium building differs strikingly from the one in the other zones. In the sunnier part of the courtyard the layer of organic debris on the pavement is thinner or even missing altogether. This is where acrocarpous mosses, especially *Bryoerythrophyllum recurvirostrum*, are most abundant.

Table 3. Bryophytes recorded from the courtyard of the herbarium building in 2010.
Nomenclature follows Sotiaux *et al.* (2007).

Liverworts
- Frullania dilatata
- Metzgeria furcata
- Radula complanata

Mosses
- Amblystegium serpens
- Barbula convoluta
- Barbula unguiculata
- Brachythecium rutabulum
- Bryoerythrophyllum recurvirostrum
- Bryum capillare
- Bryum dichotomum
- Calliergonella cuspidata
- Ceratodon purpureus
- Didymodon rigidulus
- Didymodon vinealis
- Grimmia pulvinata
- Homalothecium sericeum
- Hypnum cupressiforme
- Kindbergia praelonga
- Orthotrichum affine
- Orthotrichum diaphanum
- Oxyrrhynchium hians
- Plagiomnium undulatum
- Rhynchostegium confertum
- Rhytidiadelphus squarrosus
- Syntrichia calcicola
- Syntrichia papillosa
- Tortula muralis

Conclusion: What if ...?

In the 1930s the Belgian nature writer Michel Thiery (s.d.) wondered what would happen if all of a sudden the entire human population would disappear from the city of Ghent. He imagined how, after a couple of years, millions of young trees and shrubs start to colonize the city. Fifteen years later the cobblestones in the streets are covered with a layer of earth and dust, and an impenetrable forest has replaced the ruined and once buzzing city.

In the early 1990s the gardener left the central courtyard of the National Botanic Garden herbarium building in Meise. The aquatic plants in the pond were neglected and weed control discontinued. Irregular vegetation patterns spontaneously replaced the former geometric design of the pond garden, and the well-maintained mosaic of paving stones turned into a wooded wild garden. In two decades a lot has changed. In spring bumblebees, small tortoiseshell and comma butterfly visit the willow catkins. In summer an emperor dragonfly patrols above the pond. In late summer and autumn a kingfisher, probably a young bird in search of a vacant territory, is sometimes spotted on a willow branch. In winter mixed groups of blue, great and long-tailed tits probe twigs and buds for insects, and nuthatches relish in the presence of bird feeders that offer a mix of seeds.

March 2011. A member of the Botanic Garden staff taking a coffee break watches the scene from behind the window glass. In the courtyard the yellow catkins of goat willow provide bumblebees, hoverflies, and a single comma butterfly with nectar and pollen. Young trees compete with each other, and a thin layer of soil covers the pavement. It's a miniature version of Thiery's imaginary evolving forest come true. The scene evokes casual thoughts about man's role in nature as a manager, a restrained bystander, a conscious or unconscious dispersal agent of indigenous plants and exotics. What, the onlooker wonders, if we were to invite the gardener back into the courtyard, or a woodcutter?

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References

Geerinck D. (1997). Une végétation ligneuse subspontanée intéressante dans les interstices des pavements, à Meise et à Schaerbeek (Belgique). *Dumortiera* **67**: 13-17.

Lawalrée A. (1964). Flore générale de la Belgique. Spermatophytes. Vol. 4, fasc. 3. Bruxelles, Min. de l'Agriculture Jardin botanique de l'Etat.

Sotiaux A., Stieperaere H. & Vanderpoorten A. (2007). Bryophyte checklist and European Red List of the Brussels-Capital Region, Flanders and Wallonia (Belgium). *Belgian Journal of Botany* **140(2)**: 174-196.

Thiery M. (s.d. [1935]). Het woud. Een proeve van plantenaardrijkskunde. Gent, De Garve.

Van de Vijver B. & Compère P. (2011). Aquatic diatoms (Bacillariophyta) from a small pool at the herbarium building. *Scripta Bot. Belg.* **47**: 199-205.

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Gall causing organisms

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Résumé. – Les organismes cécidogènes du Domaine du Jardin botanique national de Belgique. Les collections vivantes ainsi que la flore spontanée du Jardin botanique offrent de belles perspectives pour l'étude des organismes cécidogènes. Cette contribution donne une liste des espèces observées depuis 2009.

Samenvatting. – Galvormende organismen in het Domein van de Nationale Plantentuin van België. De levende verzamelingen en de gevarieerde spontane flora van de Plantentuin bieden veel galvormers kansen om zich te ontwikkelen. Deze bijdrage biedt een checklist van de sinds 2009 aangetroffen soorten.

Introduction

The diverse plant collections of the National Botanic Garden of Belgium create an ideal place to find a wide range of gall forming organisms in a small area. Monitoring of plant galls provides information on new plant pests and on their host specificity. In recent years, several new species of gall forming organisms have spread across Europe in the wake of plant introductions and it is likely more will follow.

Methods

Galls were searched for in all parts of the Botanic Garden on wild and cultivated plants during 2009 and 2010. Gall forming organisms were identified by their galls, rather than by identifying the actual organism. The abundance of galls was assessed as common, uncommon or rare based on the probability of finding a gall on the host plant. If the host plant is rare in the Garden, but the gall is found on every plant, then the gall would be considered common. As there is often only a single example of cultivated taxa within the Garden for these cases the abundance is relative to the number of galls on this specimen.

Results

A full checklist of the galls found in the Garden is listed below. Gall forming organisms generally show a strong fidelity to one host, making it unusual to find galls on non-native cultivated plants. Where galls were found on alien cultivated plants they were usually on close relatives of native plants, or on hybrids where one parent was the native taxon. Three notable exceptions were the mites *Vasates quadripedes* on *Acer saccharinum*; *Obolodiplosis robiniae* on *Robinia pseudoacacia*; and *Aceria pterocaryae* on *Pterocarya stenoptera*. *Vasates quadripedes* is a North American mite, which first came to Europe around 1995 and has since been reported from many European countries (Ettis *et al.* 2005; Ripka *et al.* 2002; Wurzell 2002). In Belgium, this represents the third or fourth record of this species for the country (Prof. Jacques Lambinon, pers. communication). *Aceria pterocaryae* is from China, but was reported from the UK, France and Belgium in 2008 (Ostoja-Starzewski & Coombes 2008). *Obolodiplosis robiniae* from North America was first found in Europe in 2002 and in the Netherlands in 2007 (Docters van Leeuwen 2009).

A detailed analysis of the galls on *Quercus* species, and their host specificity, has been published separately (Groom 2010).

A Checklist of Galls in the Botanic Garden

Gall Wasps (Cynipidae)

- *Andricus callidoma* (♀♀) on *Quercus robur*. – Rare.
- *Andricus fecundator* (♀♀) on *Quercus robur*. – Uncommon.
- *Andricus grossulariae* (♂♀) on *Quercus ×hispanica* and *Quercus cerris*. – Common.
- *Andricus grossulariae* (♀♀) – Rare on *Quercus robur*. – Only one gall ever found.
- *Andricus kollari* (♀♀) on *Quercus robur*. – Common. An alien species which relies on *Quercus cerris* to complete its life cycle.
- *Andricus lignicolus* (♀♀) on *Quercus robur*. – Common. An alien species which relies on *Quercus cerris* to complete its life cycle.
- *Andricus quercuscalicis* (♀♀) on *Quercus robur*. – Common. Another alien species that relies on *Quercus cerris* to complete its life cycle.
- *Andricus quercusradicis* or *A. testaceipes* (♂♀) on *Quercus robur*. – Rare. The galls of these species are indistinguishable from each other.
- *Andricus solitarius* (♀, ♀) on *Quercus robur*. Rare.
- *Biorhiza pallida* (♂♀) on *Quercus robur*. Uncommon.
- *Callirhytis erythrocephala* (♀, ♀) on *Quercus cerris* acorns. – Common.
- *Cynips longiventris* (♀, ♀) on *Quercus robur*. Uncommon.
- *Cynips quercusfolii* (♀, ♀) on *Quercus robur*. Uncommon.
- *Cynips divisa* (♂, ♀) on *Quercus robur*. Rare.
- *Diastrophus rubi* on *Rubus fruticosus*. – Uncommon.
- *Diplolepis rosea* on *Rosa agrestis*, *R. micrantha*, *R. rubiginosa* & *R. villosa*. – There is rarely more than one gall on a bush, other rose species may be susceptible but the abundance of *Diplolepis rosea* is low. This gall has previously been reported on a wide variety of *Rosa* spp. including all the species listed above (Biological Records Centre 2009).
- *Liposthenes glechomae* on *Glechoma hederacea*. – Rare. (Fig. 1)

Figure 1. Liposthenes glechomae *on* Glechoma hederacea

- *Neuroterus albipes* (♀, ♀) on *Quercus robur*. – Common.
- *Neuroterus anthracinus* (♀, ♀) on *Quercus robur*. – Common.
- *Neuroterus numismalis* (♀, ♀) on *Quercus robur*. – Common.
- *Neuroterus quercusbaccarum* (♀, ♀) on *Quercus robur*. – Common.
- *Pediaspis aceri* on *Acer heldreichii*, *A. hyrcanum*, *A. monspessulanum*, *A. opalus* subsp. *obtusatum*, *A. pseudoplatanus* and *A. velutinum*. – Common. All species galled by this gall wasp are closely related European and Middle-eastern species, belonging to the *Acer* core clade (Grimm *et al.* 2006). Taxa ungalled by *Pediaspis aceri* in the Garden were *Acer buergerianum*, *A. cappadocicum*, *A. davidii*, *A. forrestii*, *A. ginnala*, *A. griseum*, *A. henryi*, *A. japonicum*, *A. laxiflorum*, *A. macrophyllum*, *A. negundo*, *A. oliverianum*, *A. palmatum*, *A. palmatum* subsp. *amoenum*, *A. pensylvanicum*, *A. pictum* subsp. *mono*, *A. rubescens*, *A. rubrum*, *A. saccharinum*, *A. saccharum*, *A. shirasawanum*, *A. tataricum*, *A. tetramerum*, *A. triflorum* and *A. ×freemanii*.

Gall Midges (Cecidomyiidae)

• *Contarinia tiliarum* on *Tilia ×europea*. – Rare.

• *Dasineura crataegi* on *Crataegus monogyna*. – Rare.

• *Dasineura symphyti* on *Symphytum officinale*. – Common.

• *Dasineura tiliae* on *Tilia cordata ×mongolica*. – Uncommon.

• *Dasineura ulmaria* on *Filipendula ulmaria*. – Common.

• *Dasineura urticae* on *Urtica dioica*. – Rare.

• *Hartigiola annulipes* on *Fagus sylvatica*. – Uncommon.

• *Iteomyia capreae* on *Salix caprea*. – Uncommon.

• *Iteomyia major* on *Salix cinerea*. – Uncommon.

• *Jaapiella veronicae* on *Veronica chamaedrys*. – Common.

• *Macrodiplosis dryobia* on *Q. robur*. – Common.

• *Monarthropalpus flavus* on *Buxus sempervirens*, *B. microphylla* & *B. wallichiana*. – Common.

• *Mikiola fagi* on *Fagus sylvatica*. – Common.

• *Obolodiplosis robiniae* on *Robinia pseudoacacia*. – Uncommon. First found in western Europe in 2007.

• *Wachtliella persicariae* on *Persicaria hydropiper*. – Uncommon.

• *Zygiobia carpini* on *Carpinus betulus*. – Uncommon.

Sawflies (Tenthredinidae)

• *Blennocampa phyllocolpa* on a *Rosa* sp. – Rare.

• *Pontania proxima* on *Salix nigra*. – Uncommon. Normally found on *S. alba* and other closely related native species.

• *Pontania tuberculata* on *Salix caprea*. – Uncommon.

Anthomyid Flies (Anthomyidae)

• *Chirosia betulae* on *Dryopteris filix-mas*. – Rare.

Gall Mites (Eriophyidae)

• *Acalitus brevitarsus* on *Alnus glutinosa*. – Uncommon.

• *Acalitus calycophthirus* on *Betula pubescens*. – Uncommon.

• *Acalitus stenaspis* on *Fagus sylvatica*. – Rare.

• *Aceria acericampestris* on *Acer campestre*. – Rare.

• *Aceria cephaloneus* or *A. macrorhynchus* on *Acer pseudoplantanus*. – Rare.

• *Aceria erineus* on *Juglans regia*. – Uncommon.

• *Aceria fagineus* on *Fagus sylvatica*. – Uncommon.

• *Aceria fraxinivorus* on *Fraxinus excelsior*. – Uncommon.

• *Aceria pseudoplatani* on *Acer pseudoplatanus*. – Common.

• *Aceria pterocaryae* on *Pterocarya stenoptera* and to a lesser extent on *Pterocarya ×rehderiana*. – Common, but not on *Pterocarya fraxinifolia* or *P. rhoifolia*. First found in the Garden by Jan De Langhe in June 2006.

• *Aceria ulmicola* on *Ulmus laevis*. – Uncommon.

• *Aculus fraxini* on *Fraxinus excelsior*. – Rare.

• *Cecidophyopsis atrichus* on *Stellaria graminea*. – Common.

• *Cecidophyopsis psilaspis* on *Taxus baccata*. – Uncommon.

• *Eriophyes convolvens* on *Euonymus europaeus*. – Common.

• *Eriophyes mangulis* on *Alnus glutinosa*. – Uncommon.

• *Eriophyes laevis* on *Alnus glutinosa*. – Uncommon.

• *Eriophyes platanoidetus* on *Acer platanoides*. – Rare.

• *Eriophyes tiliae* on *Tilia ×euchlora*, *T. platyphyllos* and *T. tomentosa*. – Common. Other hosts reported in the literature are *T. dasystyla* subsp. *caucasica*, *T. cordata* and *T. americana* (Buchta *et al.* 2006, Sonka 2006). However, these species were not galled by *E. tiliae* in the Garden. *Eriophyes* on *T. tomentosa* are sometimes described as either *E. tiliae tomentosae* or *E. tomentosae* (Buhr 1965, Lambinon 2009). However, it is not known if the galls on *T. tomentosa* in the Botanic Garden are caused by the same species as on *T. platyphyllos* or a different one. This question remains for future investigation.

• *Eriophyes leiosoma* and/or *Phytoptus abnormis* on *T. americana*, *T.* ×*euchlora* (*T. dasystyla* × *cordata*), *T. cordata* × *mongolia*, *T. tomentosa* and *T. platyphyllos*. – Common. *Eriophyes leiosoma* and *Phytoptus abnormis* cannot be reliably separated from their galls (Redfern and Shirley 2002).

• *Phyllocoptes coryli* on *Corylus avellana*. – Rare.

• *Phyllocoptes goniothorax* on *Crataegus monogyna*. – Rare.

• *Phytoptus avellanae* on *Corylus avellana*. – Uncommon.

• *Vasates quadripedes* on *Acer saccharinum*. – Abundant on two trees, but completely absent from two other accessions.

Aphids (Aphididae)

• *Adelges abietis* on *Picea abies*. – Common.

• *Cryptomyzus korscheltii* on *Ribes alpinum*. – Uncommon.

• *Pemphigus spyrothecae* on *Populus nigra* and *Populus laurifolia*. – Common.

Psyllids (Psylloidea)

• *Spanioneura buxi* on *Buxus sempervirens*. – Uncommon.

• *Trioza albiventris* on *Salix alba*. – Uncommon.

Fungi (Uredinales)

• *Claviceps purpurea* on *Glyceria fluitans*. – Rare.

• *Ochropsora ariae* on *Anemone nemorosa*. – Uncommon.

• *Gymnosporangium sabinae* on *Pyrus pyraster*, *P. pashia*, *P. communis* subsp. *sativa*, *Pyrus* aff. *communis* × *pyrifolia*, × *Pyronia veitchii* and *Juniperus* × *pfitzeriana*. – Common. There are also reports in the literature of this species on *Pyrus calleryana* and *P. salicifolia* (Vanderweyen & Fraiture 2008, Yun & Rossman 2009, Fraiture & Vanderweyen 2011).

• *Euphrina tosquinetii* on *Alnus glutinosa*. – Uncommon.

• *Phomopsis* sp. – Common. On *Forsythia* × *intermedia*, *F. ovata*, *F. suspensa* var. *suspensa* and *F. suspensa* var. *fortunei*, but not on *F. europaea*, *F. giraldiana* and *F. viridissima*.

• *Puccinia urticata* on *Urtica dioica*. – Uncommon.

References

Biological Records Centre (2009). – Database of Insects and their Food Plants. [http://www.brc.ac.uk/DBIF/home.aspx; accessed 14 October 2009.]

Buchta L., Kula E. & Krest'anpolova M. (2006). – Occurrence variations and spatial distribution patterns of Eriophyes tiliae (Pgst.) (Acari, Eriophyidae) subspecies in the urban environment. *Journal of Forest Science* **52(12)**: 547–555.

Buhr H. (1965). – Bestimmungstabellen der Gallen (Zoo- und Phyto-Cecidien) an Pflanzen Mittel- und Nord-Europas II. Jena, VEB Gustav Fischer Verlag.

Docters van Leeuwen, W.M. (2009). – Gallenboek: overzicht van door dieren en planten veroorzaakte Nederlandse gallen. Zeist, KNNV.

Ettis W.N. & Ulenberg S.A. (2005). – Vasates quadripedes, a gall mite (not so very) new to The Netherlands. *Entomologische berichten* **65(2)**: 52–55.

Fraiture A. & Vanderweyen A. (2011). – Gymnosporangium sabinae: such a beautiful disease. – *Scripta Bot. Belg.* **47**: 193–194.

Grimm G. W., Renner S.S., Stamatakis A. & Hemleben V. (2006). – A Nuclear Ribosomal DNA Phylogeny of Acer: Inferred with Maximum Likelihood, Splits Graphs, and Motif Analysis of 606 Sequences. *Evol. Bioinform. Online* **2**: 7–22.

Groom Q.J. (2010). – Host Specificity of Insects that Gall the Pedunculate Oak (Quercus robur L.). – *Cecidology* **25(1)**: 13–18.

Lambinon J. (2009). – Aide-memoire de cecidologie: choix zoocecidies de la Belgique. S.l.: Cercles des Naturalistes de Belgique.

Ostoja-Starzewski J.C. & Coombes A.J. (2008). – Aceria Pteroceryae (Acari: Eriophyidae), A New Addition to the British Mite Fauna. *Cecidology* **23(2)**: 42–45.

Redfern M. & Shirley P. (2002). – British Plant Galls: Identification of galls on plants and fungi. *Field Studies* **10**: 207–531.

Ripka G., Fain A., Kazmierski A., Kreiter S. & Magowski W.L. (2002). – Recent data to the knowledge of the arboreal mite fauna in Hungary (Acari: Mesostigmata, Prostigmata and Astigmata). *Opuscula* **42(3)**: 271–281.

Soika G. (2006). – Eriophyoid mites (Acari: Eriophyoidea) occurring on lime trees in ornamental nurseries. *Biological Lett.* **43(2)**: 367–373.

Vanderweyen A. & Fraiture A. (2008). – Catalogue des Uredinales de Belgique. 2ème partie. Pucciniaceae (sauf Puccinia). *Natura Mosana* **185**: 1–31.

Wurzell B. (2002). – The maple bladder gall of the gall mite Vasates quadripedes new to Britain. *Cecidology* **17**: 31–35.

Yun H.Y. & Rossman A.Y. (2009). – First Report of Gymnosporangium sabinae (European Pear Rust) on Bradford Pear in Michigan. *Plant Disease* **93(8)**: 843.

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A lichen hot spot at fifteen kilometres from the centre of Brussels

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Scripta Bot. Belg. **47**: I. Hoste (ed.), The spontaneous flora of the National Botanic Garden of Belgium (Domein van Bouchout, Meise)

Résumé. – Un hotspot de lichens à quinze kilomètres du centre de Bruxelles. Des prospections intensives du Jardin botanique national de Belgique, à Meise, ont permis de recenser 175 lichens et 14 champignons lichénicoles, un véritable hotspot près de Bruxelles. C'est jusqu'ici le site le plus riche en lichens pour la Flandre. La zone d'étude couvre 92 ha et comporte beaucoup d'arbres isolés, d'arbustes, de zones boisées, un château, beaucoup d'autres bâtiments et pierres. *Bacidia fuscoviridis*, *Clauzadea metzleri*, *Verrucaria dolosa* et *V. elaeina* ne sont actuellement connus en Flandre que de ce domaine. Plusieurs facteurs sont responsables de cette diversité: la gestion du parc, les émissions d'ammoniac, le réchauffement climatique et la grande diversité de substrats et d'habitats.

Samenvatting. – Een hotspot voor lichenen op vijftien kilometer van het centrum van Brussel. Een intensieve inventarisatie van de Nationale Plantentuin van België, in Meise, leverde 175 lichenen en 14 lichenicole fungi op. Het Domein is daarmee meteen een hotspot en voorlopig het soortenrijkste gebied in Vlaanderen. Het studiegebied van 92 ha omvat alleenstaande bomen, struikenpartijen, beboste zones, een kasteel en diverse andere gebouwen en stenen artefacten. *Bacidia fuscoviridis*, *Clauzadea metzleri*, *Verrucaria dolosa* en *V. elaeina* werden tot nog toe in Vlaanderen alleen hier aangetroffen. Meerdere factoren verklaren de soortenrijkdom, onder meer het parkbeheer, lage ammoniak-emissies, *global warming* en een grote diversiteit aan substraten en habitats.

Introduction

The National Botanic Garden of Belgium is located near the expressway A12 where every day large amounts of traffic pass by. Cars pollute the air by emissions of sulphur dioxide, ammonia and nitrogen oxides (Davies *et al.* 2007). The Botanic Garden is also situated at 15 km north of the centre of Brussels. The prevailing southwest winds blow the emissions of the city partially over this area. And finally to the southwest exists a strong concentration of livestock farms witch cause emissions of ammonia.

Most lichens are very sensitive to sulphur dioxide and nitrogen oxides. Ammonia, in contrast, leads to a shift in the species composition because it makes the bark of trees less acid and brings nitrogen in the environment. This leads to the disappearing of species that prefer or need a more nutrient-poor and/or acidic bark for the benefit of species with a preference for nutrient-rich and/or more basic bark.

On the other hand trees and parks are thought to have an air-cleaning impact e.g. by absorbtion of gaseous pollutants through the stomata (Gabriels 2008). Previous investigations of the Brussels-capital region showed that in the greener suburban areas more bryophytes and macrolichens managed to survive in comparison with the centre (Vanderpoorten 1997, Vanholen 2000). Furthermore, a previous inventory of the National Botanic Garden by the second author (Ertz 2003) already yielded surprising discoveries. In the context

of a broader investigation of the lichens in the Brabant phytogeographical district he published a list of the 25 most interesting species from this Domain. Of these 25 taxa, 5 had never been reported from Flanders before. As the main reason he mentioned insufficient prospecting with, in addition, the reduction of sulphur dioxide emissions, the increase of ammonia emissions, global warming and finally taxonomic revisions (splitting of taxa).

Could an extended research add something to these results? Additional prospects always deliver additional species. But meanwhile we are 6 years later and epiphytic lichens evolve rapidly in changing environments (van Herk 2006). All large-scale investigations of epiphytic lichens in Flanders in recent years have shown significant changes in the composition of the lichen flora (Van Eetvelde 2004, Van den Broeck & Herremans 2008c). Those changes could be linked to increased emissions of ammonia and global warming. Species that prefer higher temperatures and a less acidic bark significantly increased, while species that prefer a lower temperature and a more acidic bark significantly decreased. Are such changes also visible in the National Botanic Garden?

Results

The National Botanic Garden of Belgium proves to be a 'hot spot' for lichens and lichenicolous fungi in Flanders. Within an area of 92 ha, 189 taxa were discovered (Appendix 1). Of these 189 species, 90 grew on trees, 84 on rock, 18 on the soil, 8 on wood and 14 on lichens (a few taxa grow on different substrates). In Flanders, the hitherto richest area had 'only' 150 species (cemetery of Steenbrugge). It is important to keep the size of the area in mind. The National Botanic Garden is 92 ha, the cemetery in Steenbrugge only 12 ha. In the Netherlands the so-called 'Palace park Het Loo' at Apeldoorn is a true hot spot of epiphytic lichens (van Herk *et al.* 2004). But this park covers 650 hectares and 'only' 150 species have been recorded (on all kinds of substrates combined). Neither should we forget that most of the species there are located in a small part of the park only ('The Old Loo', 18 ha). This part of the park houses 5 species that lack in the rest of the Netherlands, and it has furthermore the highest number of Red List species (26). It is not possible to give such an exceptional rank to the National Botanic Garden. However, we are not in the Netherlands but in northern Belgium, where parks are in general characterized by fewer species (Table 1).

Another area in Flanders that was intensively prospected over a long period (11 days) is the Stramprooierbroek in the province of Limburg. Between mid-2002 and the end of 2004 van den Boom & van den Boom (2006) carefully searched all possible habitats in that area (wildlife areas, tomb stones, concrete bridges, brick walls, rocks, wood and concrete meadow poles, street trees, in all 41 sites). They discovered 'only' 159 taxa (143 lichens and 16 lichenicolous fungi), including 6 species new to Belgium. The investigated area was 32 km², while the National Botanic Garden is a little less than 1 km².

Table 1. List of parks investigated in Flanders. N = number of species

Name of the park	Commune	Surface (ha)	N	References
Tournay-Solvay Park	Watermaal-Bosvoorde	7	55	Van den Broeck *et al.* (2008a)
Rivierenhof	Deurne	130	80	De Beer & Van den Broeck (2008)
Ter Rijst	Herne en Pepingen	49.5	72	Van den Broeck *et al.* (2008b)
Château d'Attre	Attre	17	70	Van den Broeck (2007)
Vordenstein	Scholen	20	60	Slembrouck *et al.* (2004)
Boekenbergpark	Deurne	2.25	49	Hellemans & Stappaerts (2007)

During lichen surveys in the province of Antwerp, we visit per area of 16 km² all the different habitats. In areas with a church, a somewhat older and preferably walled cemetery, a not too wet nature reserve (for instance heath or forest), a number of free-standing old *Quercus*, *Tilia* or other tree species, we can find with hard work and good luck – on a single day exceptionally 100 species. But much more often fewer species are recorded.

On the first day of the inventory of the National Botanic Garden, on 09.04.2009, we recorded without any difficulty in just one third of the park (trees at the parking, the lawn near the Van Heurck auditorium, the granite poles nearby, the English bridge and the trees along the road there, a wooden bench, the plane trees near the building to the Walled Garden and the Walled Garden itself) no less than 92 species.

In the Netherlands there are 15 units (measuring each 5 × 5 km) with 180 or more species. These units have more than 25 times the surface of the National Botanic Garden. And the Netherlands have 1480 of those units. The richest unit has 203 species (Sparrius, pers. comm.).

At this moment in Flanders about 185 species of lichens are known from trees, 146 from rocks and 70 from terrestrial habitats, these numbers only include species recorded since 2001. Species that grow regularly on various substrates (e.g. both epiphytic and saxicolous) were placed in the different relevant groups. We did not separate the lignicolous taxa because very few species grow exclusively on wood and a lot of the other species are often encountered on wood. In addition, about 29 lichenicolous fungi have also been recorded. Of all the species encountered since 2001 in Flanders we discovered in the National Botanic Garden 46 % of the epiphytes, 57 % of the saxicolous lichens, 16 % of the terrestrial species and 28 % of the lichenicolous fungi.

Interesting species

The 189 species recorded from the Domain are not all more or less common. In Flanders, four of the species have been recorded from the National Botanic Garden only. Moreover, quite a few other other interesting species have been found. These are all briefly discussed below.

• *Bacidia fuscoviridis* (Anzi) Lettau
Several thalli were found on blocks of limestone. Never before reported from Flanders.

• *Bagliettoa steineri* (Kušan) Vězd
This species is typical of hard and exposed natural limestone in southern Belgium (Diederich *et al.* 2009). In Flanders it has been recorded from more artificial conditions. Previously found by Olivier Heylen in Booischot at the cemetery (not published). Ertz (2003) found *B. steineri* on a large block of limestone in the National Botanic Garden, and it was previously also spotted in Hoeilaart at the 'Ganzepootvijver', where it grows on limestone (Van den Broeck *et al.* 2008a).

• *Chaenotheca chlorella* (Ach.) Müll. Arg.
In Flanders, this species is only known from the Brabant district (6 localities). It is rarer in southern Belgium, where *C. chlorella* has been reported from 2-4 localities but it might be overlooked.

• *Chrysothrix candelaris* (L.) J. R. Laundon
This taxon has a preference for old *Quercus* (Diederich *et al.* 2009). During the current and the previous (2002-2003) inventory *C. candelaris* has been found in small quantities on a single *Fraxinus excelsior* tree. Previously, it was known in Flanders from one locality in the Park of Tervuren (Van den Broeck *et al.* 2008a) and two localities in the province of Limburg (Van den Broeck *et al.* 2006b), each time growing on *Quercus*.

• *Clauzadea metzleri* (Körb.) D. Hawksw.
C. metzleri is in Flanders only known from the National Botanic Garden where it has been found on a large block of stone (Ertz 2003).

• *Collema limosum* (Ach.) Ach.
This taxon is extremely rare in Flanders. Previously known from one locality in the Maritime district (Diederich *et al.* 2009). Only a single thallus has been found in the National Botanic Garden by Ertz in 2003. It has not been recorded during the recent investigation.

• *Melanohalea exasperata* (De Not.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch

This is an unexpected discovery. *M. exasperata* cannot be confused with any other species and has almost certainly not been overlooked in the past. This is the first record in the Brabant district since 1900. Diederich *et al.* (2009) regard this taxon as extinct for the Brabant district. Previously in Flanders only recorded from the cemetery of Blankenberge (Van den Broeck *et al.* 2006a) and the Military Domain of Leopoldsburg (Kok van Herk, not published).

• *Normandina pulchella* (Borrer) Nyl.

N. pulchella cannot be considered as a rare species in Flanders. We have found it at three different localities in the park. Moreover this taxon has been recently discovered in Flanders on a number of other sites too (e.g. the cemetery at Steenbrugge, and Stramprooierbroek). Most likely this species is spreading, although it is also easily overlooked due to its tiny dimensions.

• *Opegrapha ochrocheila* (Nyl.)

This taxon was discovered growing on stone at three different localities in the park: once on brick (Walled Garden), once on concrete, and once on limestone (ancient chapel). The main feature to distinguish *O. ochrocheila* from other *Opegrapha*'s (with 3-septate ascospores) is the presence of an orange pruina on the fruiting bodies. This pruina turns red when touched with potassium. This pruina is not always present. *O. ochrocheila* has never been reported in Belgium from stones (Diederich *et al.* 2009). Purvis *et al.* (1994) indicate that this species rarely grows on shaded silicate rocks. Furthermore some of those specimens are characterized by a white thallus while in others the thallus is invisible. It is possible that two different species are involved, but this requires further study. Most *Opegrapha*'s mentioned from Flanders from stone, previously considered to be *O. saxatilis*, probably belong to *O. ochrocheila*. This is not the case for the saxicolous specimens recorded from the Belgian coast, while these belong to *Arthonia calcarea*.

• *Opegrapha varia* Pers.

This taxon has been discovered on *Lirioden-dron*. In addition, we found green pruinose pycnidia on a brick wall, without fruiting bodies. Those pycnidia could belong to this taxon or to *O. mougeotii*. *O. varia* has never been reported in Belgium as a saxicolous species (Diederich *et al.* 2009). On the other hand Purvis *et al.* (1994) indicate that *O. varia* has rarely been recorded from shaded limestone or mortar. Recently we have found similar green pruinose pycnidia on brick of an old railway bridge in Ronse. On the same bridge we also found the orange pruinose hirellae of *O. ochrocheila*. *O. mougeotii* has never been reported from Flanders.

• *Parmeliopsis ambigua* (Wulfen) Nyl.

Parmeliopsis ambigua is nowadays extremely rare in Flanders. This species prefers acidic bark and is therefore very sensible to ammonia pollution. Hoffmann never discovered *P. ambigua* on the 32,329 trees (mainly *Populus*) he examinated in the provinces of Oost- and West-Vlaanderen (Hoffmann 1993). But even from more acidic trees this species is seldom reported. Van den Broeck *et al.* (2006b) found *P. ambigua* in Limburg on 4 of the 4670 studied oaks while Barkman (1963), who prospected the central part of Limburg in 1960, still found this taxon on 6.1 % of the locations he studied. This taxon has not been recorded during the recent inventory of the Domain.

• *Petractis clausa* (Hoffm.) Kremp.

Previously reported in Flanders from a single locality. It prefers moist and shady (natural) limestone (Diederich *et al.* 2009). In the National Botanic Garden *P. clausa* was found in the same habitat in the presence of other species that prefer similar ecological conditions (e.g. *Bacidia fuscoviridis*). In Flanders such conditions are very exceptional.

• *Physcia clementei* (Turner) Maas Geest.

This taxon is spreading. It was thought to have disappeared from Belgium (Diederich & Sérusiaux 2000) until van den Boom & van den Boom (2006) rediscovered it in the 'Stramprooierbroek' (province of Limburg). Mean-

while, this taxon has been recorded from different localities in Flanders. Possibly it will become as common as *Punctelia borreri* and *Flavoparmelia soredians*, leaf-shaped species that have shown an impressive expansion in recent years and are also present in the National Botanic Garden.

• *Physcia tribacioides* Nyl.
This taxon was reported as new for Belgium in 2006 (Van den Broeck *et al.* 2008b). Since then it has been found all over Flanders on eleven locations, including the National Botanic Garden, where it was recorded from two different trees.

• *Platismatia glauca* (L.) W.L. Culb. & C.F. Culb.
Platismatia glauca was only found once in the Domain by Ertz in 2002 on branches emerging from the crown of a tree. This taxon is rare in Flanders and very vulnerable because of its sensitivity to ammonia pollution.

• *Porpidia crustulata* (Ach.) Hertel & Knoph
P. crustulata is very common in southern Belgium but not in the north where it was previously reported from two localities (Diederich *et al.* 2009).

• *Rhizocarpon* cf. *geographicum* (L.) DC.
This taxon is less rare in Flanders than mentioned by Diederich *et al.* (2009) who consider this taxon to be extinct in the Brabant district while it was not reported after 1900. *R. geographicum* is known from 5 recent localities in the province of Antwerp (unpublished data 2003-2008).

• *Rhizocarpon reductum* Th. Fr.
Most probably overlooked, this lichen species has only recently been reported from Flanders (Van den Broeck *et al.* 2008b).

• *Schismatomma decolorans* (Sm.) Clauzade & Vězda
This unremarkable species, usually growing on old *Quercus* trees, was recently also found on smooth bark of *Populus* and *Fraxinus*. It is probably spreading.

• *Scoliciosporum gallurae* Vězda & Poelt
This species has perhaps all too often been overlooked. The thallus resembles green algae, the apothecia are very small and when they are wet they are fully translucent.

• *Staurothele frustulenta* Vain.
This species is rarely reported but not extremely rare. Diederich *et al.* (2009) mention only two Belgian localities. This species is easily confused with *Verrucaria* species but once it is well known, it can be distinguished in the field.

• *Thelidium minutulum* Körb.
Reported from Flanders by Diederich *et al.* (2009) from a single locality in the Flemish district.

• *Tubeufia heterodermiae* Etayo
This lichenicolous fungi growing on *Physcia tenella* was previously reported from Belgium from tree localties: two in Flanders and one in Wallonia. It has probably been overlooked.

• *Verrucaria dolosa* Hepp
This species had already been reported in 2003 by Ertz. In Flanders, *V. dolosa* has so far been recorded only from the National Botanic Garden.

• *Verrucaria elaeina* Borrer
Found at different places in the Domain, it had already been reported by Ertz (2003). Currently, this taxon is in Flanders only known from the National Botanic Garden.

• *Verrucaria hochstetteri* Fr.
Previously this species had been reported only once from Flanders (cemetery of Mechelen). It has a preference for soft limestone.

Discussion

The discovery of a large number of common and rare species on a relatively small area can be attributed to different factors. The most important of these are briefly discussed hereafter.

Prospection and methodological effects. The park of the National Botanic Garden was extensively and repeatedly prospected during a period of 7 years. The parks mentioned in table 1 have all been prospected for maximum one day. As a consequence, more species can be expected in these parks if they are more intensively studied.

The cemetery of Steenbrugge was also very intensively prospected over many years and this by a larger number of lichenologists than for the National Botanic Garden (Vanallemeersch 1993, Zwanepoel *et al.* 1994, Van den Broeck & Diederich 2011) and this provided 'only' 150 species.

The same applies to the cemetery of Mechelen, with a total of around 120 species. A cemetery is of course not a park: there are fewer trees and tree species and thus fewer epiphytes. Precisely this last group of lichens has in recent years been subjected to the biggest changes. We can thus assume that, over a period of 6 years, the epiphytic lichen vegetation changed, resulting in both newly arrived and disappeared species.

On the other hand, the roofs of several buildings (including the castle) have been prospected in the present study. This is certainly not usual during lichenological surveys because of obvious difficulties of accessibility. The roofs allowed us to discover 19 species (10 saxicolous taxa, 3 taxa on bryophytes and 1 lichenicolous fungus) that were not recorded elsewhere in the National Botanic Garden.

Influence of the park management. The park of the National Botanic Garden is well maintained. Lichens need light for photosynthesis. Therefore free standing and well-exposed trees are much richer in epiphytic lichens than shaded trees. A regular maintenance of the undergrowth is very much appreciated by light-loving species. Trees are generally stripped of their lower branches, allowing more light on the trunc. This promotes the growth of epiphytes. In addition, some patches of wood favour shade-loving species. Moreover, the roads are cleaned, which is beneficial for terrestrial species that cannot survive the competition with higher plants.

Influence of the air quality. The epiphytes with a preference for a nutrient-rich and less acidic bark are outnumbered in the National Botanic Garden. In the literature, this group of lichens is called nitrophytes. As a result of ammonia pollution these species can colonize also trees with a formerly acidic bark. That can be clearly observed in the Botanic Garden. Ammonia also brings a lot of nitrogen in the environment. This stimulates the presence and abundance of a second group of lichens, called neutrophytes. These latter are also well represented in the park. Species with a preference for more acidic and nutrient-poor bark (acidophytes) can also be found in the Botanic Garden but they are a minority. Three of them (*Parmelia saxatilis*, *Parmeliopsis ambigua* and *Platismatia glauca*) were absent during the current inventory. The largest source for the ammonia pollution is probably the emissions of the nearby farms.

Nothing seems to indicate some influence of pollution by sulphur dioxide on the lichens in the Domain. Since most lichens are very sensitive to sulphur dioxide, the large number of species that have been found is a counter-indication for the presence of such pollution. In addition, 5 of the 6 species with the highest degree of sensitivity to air pollution (described in Hoffmann 1993 as lichens with a high degree of poleophoby) are present in the park: *Diploicia canescens*, *Flavoparmelia caperata*, *Hypotrachyna revoluta*, *Melanelixia fuliginosa* subsp. *glabratula* and *Ramalina fastigiata*.

Impact of global warming. The encountered epiphytes are generally strongly resistant to drought and have a strong preference for warm conditions. But there is more. In comparison with 2003, a number of species new to the Botanic Garden have been recorded. Some of these are associated with the algae *Trentepohlia* (e.g. *Arthonia radiata*, *Opegrapha rufescens* and *Schismatomma decolorans*). All epiphytes with this algae as photobiont have increased dramatically in Flanders and the Netherlands in the recent past. Aptroot and Van Herk (2007) attribute this phenomenon to global warming. Some other species that have been found during the most recent prospection in 2009 (e.g. *Flavoparmelia soredians*, *Physcia tribacioides* and *Punctelia borreri*) are species that recently have increased everywhere in Flanders and the Netherlands due to their preference for warmer conditions (van Herk *et al.* 2002).

Influence of the Botanic Garden. Lichens have a succession with pioneer species (on young

substrates) which are later replaced with other species that have their optimum on older substrates. Many lichens are attached to a specific substrate. Some saxicolous species prefer a more alkaline surface (e.g. limestone, mortar, concrete), others a more acidic one (e.g. brick, granite). The presence of chalk (in the form of concrete tiles, walls flushed with calcareous mortar, etc.) also has an impact on terrestrial species, while some prefer calcareous substrates (especially species within the genus *Collema*). In addition to acidity other traits of the substrate (such as hardness and texture) also play a role. Another important factor is the degree of shade. This results in higher numbers of species when a whole range of different substrates of varying age and ecological conditions (esp. differences in light intensity) are present. This is confirmed by what we have been able to record from the National Botanic Garden. The number of tree species is very large. There are many old trees next to large numbers of young trees (e.g. in the nursery). Some parts of the Domain are densely wooded, but free-standing trees are definitely in the majority. There is furthermore a large variety of 'rocks', including the castle of Bouchout, the English bridge, the granite fence poles, the herbetum, the pebbles on the roof, the Walled Garden, the Flemish farm, and the old chapel. These include both siliceous and calcareous rocks. And not everything has the same age. The castle for instance has been cleaned about 20 years ago. The rocks are not equally well exposed to light. Near the nursery, for instance, there are a lot of shaded limestone rocks. In addition, there is a lot of wood in the park in the form of wooden benches and wooden planks on the roof of the castle. These substrates too harbour a number of typical species.

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References

Aptroot A. & van Herk C.M. (2007) – Further evidence of the effects of global warming on lichens, particularly those with Trentepohlia phycobionts. *Environmental Pollution* **146**: 293-298.

Barkman J.J. (1963) – De epifyten-flora en -vegetatie van Midden-Limburg (België). *Ver. Kon. Nederl. Akad. Wetensch. Afd. Natuurk., 2de reeks* **54 (4)**: 1-46.

Davies L., Bates J.W., Bell J.N.B., James P.W. & Purvis O.W. (2007) – Diversity and sensitivity of epiphytes tot oxides of nitrogen in London. *Environmental Pollution* **146**: 299-310.

De Beer D. & Van den Broeck D. (2008) – Verrassende mossen en lichenen in een stadspark: bezoek aan het Rivierenhof (Deurne) op 29 april 2006. *Muscillanea* **28**: 15-23.

Diederich P., Ertz D., Stapper N., Sérusiaux E., Van den Broeck D., van den Boom P. & Ries Ch. (2009) – The lichens and lichenicolous fungi of Belgium, Luxembourg and northern France. [www. lichenology.info]

Diederich P. & Sérusiaux E. (2000) – The lichens and lichenicolous fungi of Belgium and Luxembourg. An annotated checklist. Luxembourg, Musée national d'histoire naturelle.

Ertz D. (2003) – Contribution à l'étude de la flore lichénique du district brabançon belge. *Dumortiera* **81**: 81-84.

Gabriels P. (2008) – Lucht(veront)reiniging van onze steden. Ongepubl. masterproef Hogeschool Antwerpen.

Hellemans K. & Stappaerts H. (2007) – Een bezoekje aan de lichenen van het Boekenbergpark (Deurne, Antwerpen). *Muscillanea* **26**: 12-14.

Hoffmann M. (1993) – Verspreiding, fytosociologie en ecologie van epifyten en epifytengemeenschappen in Oost- en West-Vlaanderen. Ongepubl. doctoraatsverhandeling Universiteit Gent, faculteit wetenschappen.

Purvis O.W., Coppins B.J., Hawksworth D.L., James P.W. & Moore D.M. (1994) – The Lichen Flora of Great Britain and Ireland. London, Natural History Museum Publications & British Lichen Society.

Slembrouck J., Van den Broeck D. & Janssens C. (2004) – Mossen en lichenen in het Domein Vordenstein (Prov. Antwerpen, Schoten). *Muscillanea* **24**: 13-26.

Vanallemeersch R. (1993) – Een vegetatiekundige en ecologische studie van de epilietenvegetaties op het Bridges kerkhof. Ongepubl. licentiaatsverhandeling Universiteit Gent.

van den Boom P. & van den Boom B. (2006) – An inventory of lichens and lichenicolous fungi in northern Belgium (area of Stramproenerbroek). *Bull. Soc. Nat. Luxemb.* **106**: 39-52.

Van den Broeck D., Aptroot A. & Jordaens D. (2006a) – Een lichenologisch verslag van het voorjaarsweekend 2006 naar Zeeuws Vlaanderen en aangrenzend België. *Buxbaumiella* **75**: 16-25.

Van den Broeck D., Polfliet L., Herremans M., Vanreusel W. & Verbeylen G. (2006b) – Monitoring van am-

monitak en zwaveldioxide met korstmossen in Limburg. Eindverslag Bijzonder Leefmilieuproject t.s.m. Provincie Limburg 2005-2006. Rapport Natuurpunt Studie 2007/7. Mechelen, Natuurpunt.

Van den Broeck D. (2007) – De lichenen van het kasteeldomein van Attre (VWBL-excursie 14 juni 2003). *Muscillanea* **26**: 27-31.

Van den Broeck D., Herremans M., Polfliet T., Vanreusel W. & Van Dorsselaer P. (2007) – Monitoring van ammoniak en zwaveldioxide met korstmossen in Vlaams-Brabant. Eindverslag bijzonder natuurbeschermingsproject t.s.m. Provincie Vlaams-Brabant 2006-2007. Rapport Natuurpunt Studie 2006/5. Mechelen, Natuurpunt.

Van den Broeck D., Spier L. & Ertz D. (2008a) – Verslag van de internationale korstmossendriedaagse in en rond het Zonienwoud, 1-3 juni 2007. *Muscillanea* **27**: 25-37.

Van den Broeck D., Jordaens D., Sparrius L., Spier L. & Aptroot A. (2008b) – Nieuwe lichenen en lichenicole fungi uit Vlaanderen. *Dumortiera* **95**: 8-14.

Van den Broeck D. & Herremans M. (2008c) – Korstmossen als indicatoren voor milieukwaliteit: Ammoniak en temperatuurstijging als sturende factoren. *Natuurfocus* **4**: 128-134.

Van den Broeck D., De Beer D. & Stieperaere H. (2008d) – De lichenen en mossen van de VWBL-excursie naar het domein Ter Rijst in Vlaams-Brabant (7 april 2007). *Muscillanea* **28**: 4-11.

Van den Broeck D. & Diederich P. (2011) – Het kerkhof van Steenbrugge: het kerkhof met de meeste soorten lichenen en lichenicole fungi in Vlaanderen. *Muscillanea* **30**: 12-21.

Vanderpoorten A. (1997) – A bryological survey of the Brussels Capital Region (Belgium). *Scripta Botanica Belgica* **14**. Meise, National Botanic Garden of Belgium.

Van Eetvelde J. (2004) – Evolutie van de epifytenflora in de Denderstreek sinds 1962: lenden veranderingen in luchtverzuringstoestand tot soortenshifts? Ongepubl. licentiaatsverhandeling Universiteit Gent, Faculteit wetenschappen.

van Herk C.M., Aptroot A. & van Dobben H.F. (2002) – Long-term monotoring in the Netherlands suggests that lichens respond to global warming. *Lichenologist* **34** (2): 141-154.

van Herk C.M., Aptroot A., Sparrius L.B. & Spier J.L. (2004) – Paletspark Het Loo bij Apeldoorn, een ware hot spot voor epifytische korstmossen. *Buxbaumiella* **69**: 9-16.

van Herk C.M. (2006) – Korstmossen in Overijssel: milieuindicatie, natuurwaarde, veranderingen 1989-2005. ION in opdracht van de Provincie Overijssel, eenheid Landbouw, Natuur & Landschap, team Natuur en Landschap, Soest.

Vanholen B. (2000) – Epifytische macrolichenen van het Brussels Hoofdstedelijk Gewest. *Scripta Botanica Belgica* **26**. Meise, Nationale Plantentuin van België.

Zwaenepoel A., Hoffmann M. & Vanallemeersch R. (1994) – Mossen, korstmossen en varens op de muren en grafstenen van het Brugs kerkhof. *Gentse Bijdragen* **94**(4): 27-38.

Appendix 1. Species list of lichens and lichenicolous fungi recorded from the Domain of the National Botanic Garden of Belgium

Lichenicolous fungi are marked by an asterisk (*) before their names.

Acarospora rufescens	Saxicolous (granite pegs, pebbles on roof)
Anisomeridium polypori	*Acer, Fraxinus, Sambucus,...*
**Arthonia lecanorina*	*Lecanora albescens* (on wall at the roof of the castle)
**Arthonia phaeophysciae*	*Phaeophyscia orbicularis* (roof of the castle, *Paulownia*)
Arthonia radiata	*Catalpa fargesii, Fraxinus angustifolia, Gleditsia triacanthos, Populus violascens,...*
Arthonia spadicea	*Alnus glutinosa, Fraxinus excelsior,...*
Arthopyrenia punctiformis	*Alnus glutinosa*
Aspicilia calcarea	Roof of the castle (slabs), boulders on the ground near the castle, rocks in the park,...
Aspicilia contorta subsp. *contorta*	Pebbles on the roof, Walled Garden,...
Aspicillia contorta subsp. *hoffmanniana*	Rocks in the park
**Athelia arachnoidea*	*Acer negundo, Cercis, Malus yunnanensis,* (algae, *Xanthoria parietina*)
Bacidia fuscovirdis	Saxicolous (limestone)
Bacidina caligans	Concrete, on soil (rose garden)
Bacidina chloroticula	Lignicolous (Walled Garden)
Bacidina neosquamulosa	Wall (concrete), *Fagus, Fontanesia phillyreoides*
Baglietto calciseda	Wall of castle, rocks in the park
Baglietto steinen	Rocks in the park
Bilimbia sabuletorum	Wall (Walled Garden), rocks in the park
Buellia aethalea	Slates (castle)
Buellia griseovirens	*Juglans*
Buellia punctata	*Acer, Carpinus, Elaeagnus, Fraxinus, Hamamelis, Juglans, Sorbus,* wooden boards on the roof of the castle, wooden benches, granite,...
**Burgoa angulosa*	*Physcia tenella* on *Tetradium daniellii*
Caloplaca aurantia	Old farm near the castle (limestone board), Flemish farm (limestone on the soil), limestone
Caloplaca chrysodeta	Walled Garden (on the wall)
Caloplaca citrina	Granite, wall of the castle,
Caloplaca coronata	Boulders on the ground near the castle
Caloplaca decipiens	Roof and wall of the castle
Caloplaca flavescens	Wall of castle (downstairs and on the roof), Flemish farm (limestone on the ground)
Caloplaca flavocitrina	Wall (concrete),
Caloplaca dolomiticola	Concrete (tiles Walled Garden), rocks
Caloplaca holocarpa	Concrete, granite,
Caloplaca lithophila	Concrete, rocks,
Caloplaca obscurella	*Liriodendron tulipifera, Salix,*
Caloplaca pyracea	*Populus*
Caloplaca ruderum	Brick wall, wall of the castle
Caloplaca saxicola	Wall of the castle, rocks,
Caloplaca subpallida	Slates on the roof of the castle
Caloplaca teicholyta	Wall and roof of the castle
Candelaria concolor	*Euonymus, Juglans, Populus*
Candelariella aurella	Concrete, granite, wall of the castle, rocks in the garden,
Candelariella medians	Wall of the castle
Candelariella reflexa	*Aesculus, Elaeagnus, Hamamelis, Juglans, Populus, Sorbus, Paulownia,*
Candelariella vitellina	Wooden boards on the roof of the castle, wooden benches, slates on the roof of the castle,
Catillaria chalybeia	Pebbles on the roof, boulders on the roof of the castle, acid stones (castle)
Catillaria lenticularis	Wall of the castle
Catillaria nigroclavata	*Amorpha fomentosa, Paulownia*

Chaenotheca chlorella	*Fraxinus excelsior*
Chaenotheca ferruginea	*Castanea sativa, Quercus,..*
Chaenotheca trichialis	*Castanea sativa, Fraxinus, Quercus,..*
Chrysothrix candelaris	*Fraxinus excelsior*
Cladonia chlorophaea	*Crataegus pinnatifada*
Cladonia coniocraea	*Acer*
Cladonia fimbriata	Roof, wooden beams (greenhouse Herbetum)
Cladonia furcata	On soil (nursery)
Cladonia grayi	On the roof on mosses
Cladonia humilis	*Fagus*, on soil (nursery)
Cladonia subulata	On the roof on mosses
Clauzadea metzleri	Limestone
Coenogonium pineti	*Carpinus, Corylus, Crataegus laevigata, Fraxinus excelsior, Quercus, Tilia,...*
Collema crispum	Walled Garden, soil along the road,
Collema limosum	Soil
Diplotomma alboatrum	Wall of the castle
Evernia prunastri	*Acer monspessulanum, Aesculus, Cercis, Crataegus laevigata,Elaeagnus, Paulownia,..*
Fellhanera viridisorediata	*Quercus*
Flavoparmelia caperata	*Acer monsepessulanum, Cercis, Euonymus europaeus, Juglans,Quercus,...*
Flavoparmelia soredians	*Aesculus, Malus yunnanensis*
Halecania viridescens	*Albizia julibrissin, Cercis, Crataegus pinnatifida, Syringa*
Hyperphyscia adglutinata	*Hamamelis, Juglans, Paulownia, Sorbus,*
Hypocenomyce scalaris	*Quercus*
Hypogymnia physodes	*Malus toringioides, Paulownia, Populus, Sorbus,*
Hypogymnia tubulosa	*Aesculus, Cercis, Gleditsia triacanthos*
Hypotrachyna afrorevoluta	*Acer monspessulanum, Aesculus, Crataegus laevigata, Euonymus europaeus, Malus yunnanensis*
Hypotrachyna revoluta	*Cercis, Cydonia oblonga*
**Illosporiopsis christiansenii*	On *Physcia* sp. on several different trees
Jamesiella anastomosans	*Catalpa* aff. *bignonioides, Fagus, Prunus pendula, Quercus*
Lecania cyrtella	*Hibiscus, Juglans, Sambucus*
Lecania erysibe	Concrete
Lecania naegelii	*Fraxinus, Salix, Ulmus glabra*
Lecania rabenhorstii	Rocks in the park
Lecanora albescens	Concrete, wall and roof of the castle, rocks
Lecanora barkmaniana	*Aesculus sylvatica, Catalpa fargesii, Juglans*
Lecanora campestris	Saxicolous, wooden boards at the roof of the castle
Lecanora carpinea	*Gleditsia triacanthos, Sorbus,*
Lecanora chlarotera	*Castanea, Fraxinus, Juglans, Paulownia, Sorbus*
Lecanora compallens	*Juglans*
Lecanora conizaeoides	*Castanea, Quercus,*
Lecanora crenulata	Wall of the castle, Walled Garden: old chapel,
Lecanora dispersa	Wall, granite, rocks, *Populus violascens*
Lecanora dispersella	Wooden bench
Lecanora expallens	*Corylus, Fraxinus, Paulownia*
Lecanora hagenii	*Elaeagnus, Fraxinus, Hamamelis, Juglans, Paulownia*, saxicolous (granite, brick)
Lecanora muralis	Concrete, granite, wooden boards on the roof of the castle, pebbles on the roof, slates on the roof of the castle, rocks
Lecanora polytropa	Wooden benches, wooden boards on the roof of the castle, pebbles on the roof
Lecanora saligna	*Ginkgo biloba*
Lecanora semipallida	Saxicolous (limestone, concrete,...)
Lecanora symmicta	*Cercis, Gleditsia triacanthos, Quercus*
Lecidea fuscoatra	Wooden boards on the roof of the castle, pebbles on the roof
Lecidella carpathica	Wooden boards on the roof of the castle

Lecidella elaeochroma	*Aesculus*, *Amorpha tomentosa*, *Cercis*, *Davidia involucrata*, *Elaeagnus*, *Hamamelis*, *Juglans*, *Sorbus*,...
Lecidella stigmatea	Concrete (wall), granite, wooden boards on the roof of the castle, pebbles on the roof,...
Lempholema chalazanum	Walled Garden, rose garden (castle), soil along the road
Leprana incana	*Castanea*, *Corylus*, *Crataegus laevigata*, *Euonymus europaeus*, bitumen on the roof,...
Leprana lobificans	*Crataegus pinnatifada*, *Physocarpus opulifolius*
Leprana vouauxii	English bridge, Walled Garden
**Lichenodiplis lecanorae*	*Lecanora saligna (Ginkgo biloba)*
**Marchandiobasidium aurantiacum*	*Aesculus* (on *Physcia adscendens*)
Melanelixia fuliginosa subsp. *glabratula*	*Acer negundo*, *Crataegus laevigata*
Melanelixia subaurifera	*Acer monspessulanum*, *Aesculus*, *Cercis*, *Malus yunnanensis*, *Sorbus*, granite,...
Melanohalea exasperata	*Gleditsia triacanthos*
Melanohalea exasperatula	*Acer monspessulanum*, *Catalpa fargesii*
Micarea denigrata	Lignicolous (Walled Garden), wooden bench
Micarea micrococca	*Crataegus laevigata*
Micarea prasina	Tree stump
Micarea viridileprosa	*Liriodendron tulipifera*
Normandina pulchella	cf. *Euonymus*, *Catalpa*, *Crataegus pinnatifida*
Opegrapha niveoatra	*Platanus*
Opegrapha ochrocheila	Wall (Walled Garden), old chapel
Opegrapha rufescens	*Fraxinus pennsylvanica*, *Fraxinus xanthoxyloides*, *Pterocarya*,...
**Opegrapha rupestris*	*Baglietoa calciseda* (wall of the castle and rocks in the park)
Opegrapha vana	*Liriodendron tulipifera*, brick wall (Walled Garden)
**Paranectria oropensis*	*Acer negundo* (on *Melanelixia fuliginosa* subsp. *glabratula*), *Cercidophyllum japonicum* (on *Leprana incana*), *Magnolia* (on *Lepraria*), *Malus toringoides* (on *Leprana incana* and *Physcia tenella*),...
Parmelia saxatilis	Bark
Parmelia sulcata	*Acer monspessulanum*, *Cercis*, *Elaeagnus*, *Hamamelis*, *Malus yunnanensis*, *Paulownia*, wooden beams (greenhouse Herbetum),...
Parmelina tiliacea	*Prunus pendula*
Parmeliopsis ambigua	*Ulmus*
Parmotrema perlatum	*Aesculus*, *Zanthoxylum simulans*,
Peltigera rufescens	On the soil of the rose garden near the castle
Petractis clausa	On limestone
Phaeophyscia nigricans	*Hamamelis*, *Juglans*, wall on the roof of the castle, rocks
Phaeophyscia orbicularis	Bark (of many tree species) and saxicolous (limestone, concrete, acid stones)
Phlyctis argena	*Acer tartancum*, *Fontanesia phillireoides*,
Physcia adscendens	*Acer negundo*, *Elaeagnus*, *Fraxinus*, *Hamamelis*, *Juglans*, *Paulownia*, *Sorbus*, saxicolous (limestone, acid stones)
Physcia aipolia	*Populus*
Physcia caesia	Roof of the castle, granite, pebbles on the roof,
Physcia clementei	*Acer tartancum*
Physcia dubia	Slates on the roof of the castle
Physcia stellaris	*Cercis*
Physcia tenella	*Acer monspessulanum*, *Amorpha tomentosa*, *Cercis*, *Elaeagnus*, *Fraxinus*, *Juglans* , *Malus yunnanensis*, granite,
Physcia tribacioides	*Tetradium daniellii*, *Diopyros lotus*
Physconia grisea	*Juglans*, *Populus*,
Platismatia glauca	*Fraxinus*
Placynthiella icmalea	*Albizia julibrissin*, wooden bench, wooden beams (greenhouse Herbetum)
Pleurosicta acetabulum	*Fraxinus*
Polysporina simplex	Slates on the roof of the castle
Porina aenea	*Acer negundo*, *Aesculus*, *Carpinus*, *Corylus*, *Crataegus pinnatifida*, *Laburnum anagyroides*,
Porina chlorotica	Saxicolous (limestone)

Porpidia crustulata	Saxicolous (nursery), pebbles on the roof
Porpidia soredizodes	Wooden boards on the roof of the castle, pebbles on the roof, silicious rocks
Porpidia tuberculosa	Brick wall (Walled Garden)
Protoblastenia rupestris	Concrete (greenhouse Herbetum), limestone (nursery), rocks in the park
Psilolechia leprosa	Saxicolous
Psilolechia lucida	Brick wall (e.g. Flemish farm)
Punctelia borreri	*Cercis*, *Maackia amurensis*,..
Punctelia jeckeri	*Acer negundo*, *Aesculus*, *Carpinus turczaninowii*, *Cydonia oblonga*, *Paulownia*,...
Punctelia subrudecta	*Aesculus*, *Amorpha tomentosa*, *Fraxinus*, *Elaeagnus*, wooden boards on the roof of the castle
Ramalina farinacea	*Carpinus turczaninowii*
Ramalina fastigiata	*Cercis*
Rhizocarpon cf. *geographicum*	Pebbles on the roof
Rhizocarpon reductum	Pebbles on the roof
Rinodina oleae	Wall of the castle, granite, rocks in the park,
Sarcogyne regularis	Rocks in the park and pebbles on the roof of the castle
Sarcosagium campestre s.l.	Walled Garden (on soil)
Schismatomma decolorans	*Fraxinus excelsior*
Scoliciosporum gallurae	*Diospyros lotus*
Staurothele frustulenta	Concrete (tiles near the garage)
Strangospora pinicola	*Quercus*
**Syzygospora physciacearum*	*Prunus pendula* (on *P. tenella*), *Quercus* (on *Physcia adscendens*)
Thelidium minutulum	Small pebbles on the ground of a road
Trapelia coarctata	Pebbles on the roof
Trapelia placodioides	Pebbles on the roof, Flemish Farm (wall)
Trapeliopsis flexuosa	Wooden beams (greenhouse Herbetum), wooden benches, boards on the roof of the castle
Trapeliopsis granulosa	Wooden boards on the roof of the castle
Trapeliopsis pseudogranulosa	*Fagus*
**Tubeufia heterodermiae*	*Physcia tenella* on *Tetradium daniellii*
Usnea spec.	*Catalpa* aff. *bignonioides*, *Cercis*, *Quercus cerris*
Verrucaria bryoctona	Mosses on the roof of the castle
Verrucaria dolosa	Limestone block
Verrucaria elaeina	Concrete
Verrucaria macrostoma	Concrete
Verrucaria muralis	Concrete, soil, pebbles in the park, mortar,
Verrucaria nigrescens	Wall of the castle,
Verrucaria viridula	Boulders on the ground near the castle, rocks in the park
Xanthoria calcicola	Walls on the roof of the castle
Xanthoria candelaria	*Carpinus turczaninowii*, *Gleditsia triacanthos*
Xanthoria elegans	Granite, pebbles on the roof, rocks in the park
Xanthoria parietina	*Acer negundo*, *Elaeagnus*, *Fagus*, *Fraxinus*, *Juglans*, *Hamamelis*, *Paulownia*, *Sorbus*, saxicolous (limestone, granite),
Xanthoria polycarpa	*Aesculus*, *Fraxinus*, *Lonicera*, *Sorbus*, granite, polyester on the roof
**Xanthonicola physciae*	*Xanthoria parietina* (*Aesculus*, *Paulownia*, ...)

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Laboulbeniales (Ascomycetes)

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Résumé. – Laboulbeniales (Ascomycetes) du Domaine de Bouchout (Meise, Belgique). L'étude d'une série de coléoptères échantillonnés dans le domaine du Jardin botanique national de Belgique (Domaine de Bouchout à Meise) a permis d'identifier 34 espèces de Laboulbeniales (Ascomycetes), dont *Aphanandromyces audisioi* W. Rossi est nouvelle pour la Belgique. Les coléoptères carabes (Carabidae) et les staphylins (Staphylinidae) constituent les groupes d'hôtes les plus importants. Le nombre de Laboulbeniales culmine dans l'aulnaie-frênaie ainsi que dans une prairie humide limitrophe. Des commentaires sont donnés pour chaque espèce rare ou chaque combinaison avec un hôte peu commun. Certaines associations laissent supposer que les infections fortuites ne sont pas rares dans l'aulnaie-frênaie. Les données de cette étude constituent une référence pour le monitoring local (le domaine) ou régional des coléoptères et de leur communauté de parasites.

Samenvatting. Laboulbeniales (Ascomycetes) van het Domein van Bouchout (Meise, België). Een reeks Coleoptera verzameld in het domein van de Nationale Plantentuin van België (Domein van Bouchout, Meise) werd gescreend voor Laboulbeniales (Ascomycetes). In totaal werden 34 soorten gevonden, *Aphanandromyces audisioi* W. Rossi is nieuw voor België. Loopkevers (Carabidae) en Kortschildkevers (Staphylinidae) zijn de belangrijkste gastheergroepen, met het hoogst aantal soorten Laboulbeniales in een essen-elzen bronbos en een aanpalend vochtig grasland. Enkele zeldzame soorten en nieuwe parasiet-gastheer combinaties worden besproken. De nieuwe parasiet-gastheer combinaties tonen aan dat toevallige infecties vrij frequent zijn in het bronbos. De basisgegevens uit deze studie vormen een referentie voor de monitoring van de kever- en parasietengemeenschap in het Domein en de regio.

Introduction

Laboulbeniales (Ascomycetes) are obligate ectoparasites from Arthropoda. They are host-specific and parasitize mainly Hexapoda. About 2050 species are known worldwide (Kirk *et al.* 2008), 400 are reported from Europe and 107 from Belgium. The distribution of most taxa is poorly known. Some species are cosmopolitan, but the majority is known from a few countries and a few localities. Most laboulbenologists study taxonomy and systematics, while only a few study ecology, habitat preference and distribution (among others Scheloske 1969, Majewski 1994b, 2003). In Belgium a lot of work was done to better understand the impact of host and habitat on Laboulbeniales, as well as the mechanisms that drive host-specificity, population dynamics and transmission (De Kesel 1995, 1996). In this context the Domain of Bouchout (Meise, Vlaams-Brabant) was used as a study site for Laboulbeniales. Coleoptera were sampled from 1992 till 1993 in a small hillside spring ash-alder forest and an adjacent humid grassland in sector 44. The infection data (infection frequency and thallus density) obtained from this sampling campaign was compared to data from other sites (in Flanders) and helped to understand the gender-related infection patterns in *Chrysina fos-*

sor (Coleoptera, Carabidae) and the population dynamics of its parasite *Laboulbenia clivinalis* (De Kesel 1995). The samples also contained some Staphylinidae (Coleoptera) and Byrrhidae (Coleoptera) infected with interesting and new species for science, i.e. *Peyritschiella heinemanniana* De Kesel and *Phaulomyces simplocariae* De Kesel. In response to a call for a commented biodiversity inventory of the Domain of Bouchout, we screened all the remaining insects available from the collecting campaign (1992-1993) and sampled a number of new areas we thought interesting. The results are presented here as the first commented inventory of the Laboulbeniales and their hosts of the Domain of Bouchout in Meise, a large park that houses the National Botanic Garden of Belgium.

Materials and methods

The insects were caught from February 1992 till November 1993 by means of 30 pitfall traps (diameter 9 cm, filled with 50 ml 2 % formol, emptied every fortnight). The traps were placed in sector 44 (see fig. 1) of the Domain, i.e. in a hillside spring ash-alder woodland (50° 55' 35,75" N, 04° 19' 15,70" E) and in an adjacent wet grassland (50° 55' 35,46" N, 04° 19' 16,03" E).

Figure 1. Location of sector 44 in the Domain of the Botanic Garden. In this sector insects were caught during 1992-1993.

The grassland is fairly eutrophic, not species rich and mown once a year (in June-July). In the past the drainage of the grassland was improved by building a central ditch and applying a drainage layer with stone debris.

The ash-alder woodland seems more spontaneous, it stretches about 100 m along the base of a south-east facing hill. It's about 30m wide, with a moderate slope (less than 5°) and gradually becoming flat. It drains in an artificial ditch separating it from the above mentioned grassland. In the lower half of the forest, cool alkaline water continuously seeps from the soil, creating 2-3 small rivulets and puddles filled with organic debris covered or trapped in travertine. This typical aspect is best developed in the most western part. This part is also very shady and lacks a well-developed layer of herbaceous plants. The forest floor and dead branches are often partly or entirely overgrown with *Hedera helix*, and with *Brachythecium rivulare* Schimp. among other mosses.

All collected insects were labeled and preserved in 70-90° denatured ethanol. Screening of specimens was done using a stereomicroscope at 40-50× magnification. Thalli were removed and mounted on permanent slides following the protocol in Benjamin (1971) and De Kesel (1998a). The microscope slide collection and all infected insects are kept at the Herbarium of the National Botanic Garden of Belgium (BR). Drawings were made from intact specimens, using an Olympus BX51 light microscope with drawing tube, measurements were made using the microscope's digital camera and AnalySIS Five imaging software (Soft Imaging System GmbH). The nomenclature for genera of Laboulbeniales follows Tavares (1985). Parasite-host lists and identification keys for species were taken from De Kesel (1998a, 2002, 2004), De Kesel & Haghebaert (1991), De Kesel & Rammeloo (1992), Majewski (1994a), Santamaria (1998, 2003) and Santamaria *et al.* (1991). The nomenclature of Staphylinidae is according to Lohse (1964), Lohse *et al.* (1974), including additions in Segers (1986) and Drugmand (1986). Carabidae were identified with Bocken (1987), the nomenclature follows Desender (1995).

Results and discussion

The list of Laboulbeniales from the Domain of Bouchout (Meise, Belgium) presents the genera and species alphabetically. Per Laboulbeniales species, the hosts are given [Family], their habitat, collecting date and the slide numbers. Descriptions and comments on anatomy, ecology or distribution are given only for the most interesting species. Taxa from the ash-alder forest are marked with an asterisk (*).

• *Aphanandromyces audisioi* W. Rossi *

Brachypterus urticae (Fabricius, 1792) [Nitidulidae]: on *Urtica dioica*, ash-alder forest, 04.08.2008, ADK4672a,b,c.

Description (Figure 2) Thallus yellowish to amber colored, 230-270 µm long. Receptaculum three-celled; cell I rhomboid, slightly higher than broad; cell II somewhat flattened, supporting cell VI at its apex, separated from cell III by a vertical septum; cell III slightly larger and taller than cell II. Primary appendage usually damaged in adult thalli; basal cell wedge-shaped, triangular in optical section; supra-basal cell triangular, with a lateral knob near the base (abaxial) and a pointed projection at the apex carrying the antheridial branch (usually missing in adult thalli; details are given in Santamaría 2003). Perithecium 125-145 × 50-55 µm, somewhat spindle-shaped,

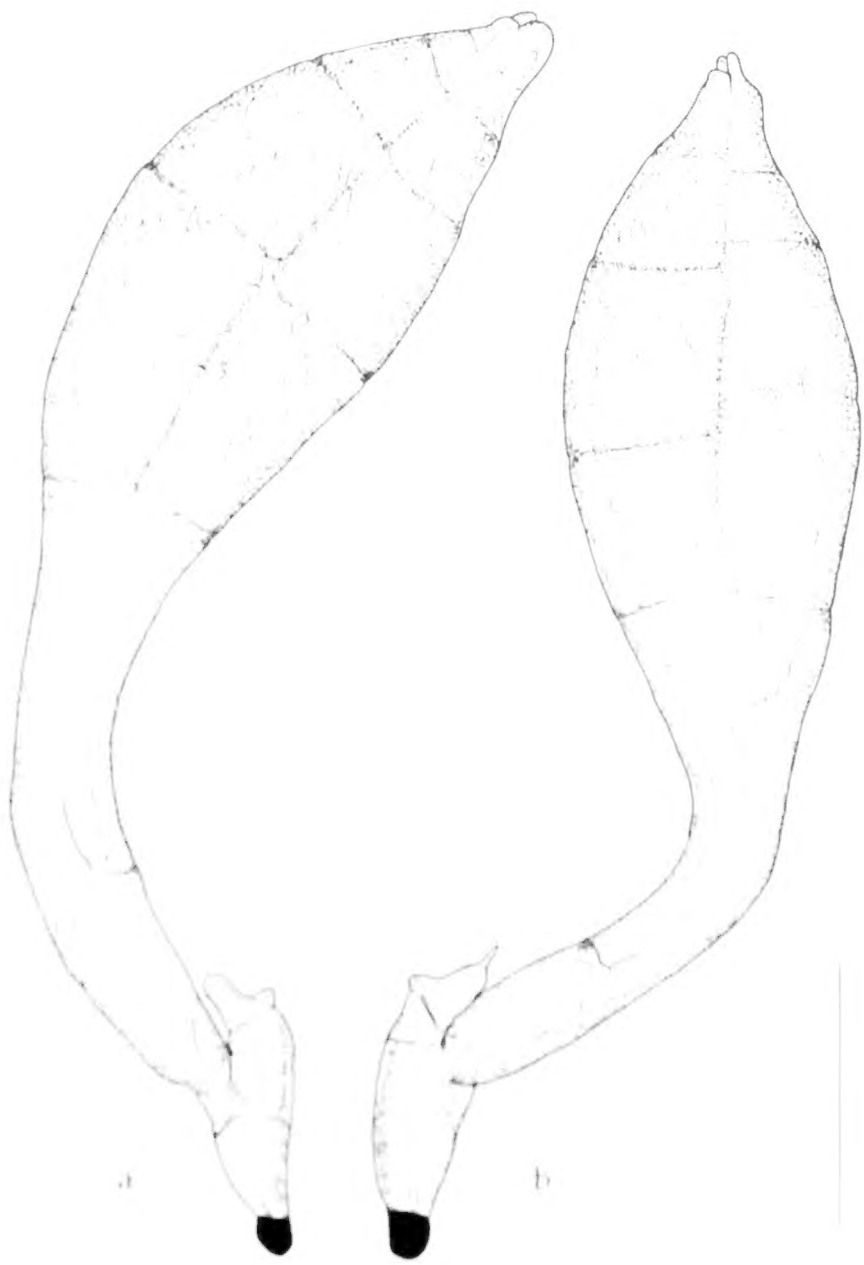

Figure 2. Aphanandromyces audisioi *W. Rossi*. *a* adult thallus with turned perithecium (ADK4672b); *b* adult thallus with normal orientation of the perithecium (ADK4672a); antheridial branch missing in both thalli. Scale bar = 50 µm.

long stalked, slightly asymmetrical, the dorsal side more curved, widest near the centre (middle), gradually tapering towards the apex. Perithecial wall composed of 4 vertical series of cells, each consisting of 5 cells of unequal height, the tallest cells below and forming the venter of the perithecium. Ostiolum composed of 4 cells of unequal height, with undifferentiated lips, the two dorsal cells smaller than the ventral ones. Perithecial stalk 115-145 µm long, composed of cell VI, VII and the two basal cells of the perithecium, the latter together about 1.5-2 times as long as cell VI. Cell VI supported by cell II, and separated from it by a strongly constricted and hyaline septum. Ascospores 30-40 µm long, covered by a mucilaginous layer, bi-cellular, the larger cell 4 times taller than the smaller cell.

Aphanandromyces audisioi occurs exclusively on *Brachypterus urticae*, a very common beetle from the Nitidulidae that feeds on the male inflorescences of *Urtica dioica*. *A. audisioi* is reported from Italy (Rossi 1982) and Spain (Santamaria 2003), where it is only known from mountainous areas. The species was also reported from France, Sweden (Santamaria *et al.* 1991), the United Kingdom (Weir 1996), Lithuania (Markovskaja 2000) and Latvia (De Kesel & Krastina 2006). A large number of Belgian localities with *B. urticae*, outside the Domain have been screened for *A. audisioi*. So far only a few of these sites have infected host populations (De Kesel unpubl.) which leads to the conclusion that *A. audisioi* is much less common in Belgium (northern part) than, for instance, in Poland (Majewski 1994a,b, 2003). More research is needed to explain why *A. audisioi* is completely missing in wet areas with high densities of *Urtica dioica* and *Brachypterus urticae*.

• *Isaphomyces tubanticus* (Boelens ex Middelh. & Boelens in Middelh.) Scheloske

Catops nigricans (Spence, 1815) [Catopidae]: grassland, 24.03.1993, ADK4712.

• *Cantharomyces orientalis* Speg.*

Carpelimus corticinus (Gravenhorst, 1806) [Staphylinidae]: ash-alder forest, in litter, 25.06.2009, ADK4721.

• *Cantharomyces robustus* I. Majewski*

Carpelimus sp. [Staphylinidae]: ash-alder forest, in litter, 25.06.2009, ADK4719, ADK4720, ADK4722, ADK4723.

• *Compsomyces lesteviae* Thaxt.*

Lesteva heeri Fauvel, 1872 [Staphylinidae]: ash-alder forest, 24.03.1993, ADK4715, ADK4716.

• *Corethromyces stilici* Thaxt.*

Rugilus sp. [Staphylinidae]: ash-alder forest, 19.05.1993, ADK4700.

• *Cryptandromyces* sp.

Brachygluta sp. [Pselaphidae]: grassland, 05.05.1993, ADK4692.

This taxon's epithet could not be determined with certainty since the thalli are not fully developed. *Cryptandromyces* has a wide circumscription, including monoecious as well as dioecious taxa, and allowing important differences in the construction of the receptaculum and the number of perithecial wall cells. Representatives of *Cryptandromyces* are found on Scydmaenidae, Pselaphidae (Coleoptera) and Forficulidae (Dermaptera, earwigs). Four species are reported from Europe, two from Belgium (unpubl. data), all on Pselaphidae. More collecting is needed in order to find hosts infected with mature and fully developed thalli.

• *Euzodiomyces lathrobii* Thaxt.*

Lathrobium elongatum (L., 1767) [Staphylinidae]: grassland, 05.05.1993, ADK4694c, ADK4695.

Patrobus atrorufus (Ström, 1768) [Carabidae]: ash-alder forest, 23.09.1992, ADK692, ADK693.

Pterostichus strenuus (Panz., 1797) [Carabidae]: ash-alder forest, 18.11.1992, ADK654.

Euzodiomyces lathrobii is known from Belgium (Collart 1945, De Kesel & Haghebaert 1991, De Kesel & Rammeloo 1992) and eleven more European countries, but also Algeria (Santamaria *et al.* 1991), North America (Benjamin & Shanor 1951) and Japan (Sugiyama 1973). This species has a wide host range including several genera of Staphylinidae, but the main hosts belong to the genus *Lathrobium*.

Grav. (Frank 1982). Scheloske (1969) mentions the carabid beetle *Patrobus atrorufus* as an occasional host for *E. lathrobii*. Although it is considered a rare combination, it is fairly common in our study site (ash-alder forest). The combination with *P. strenuus* is new, but not unexpected, considering the very high thallus densities on the *Lathrobium* population in this site. The thalli found on *P. atrorufus* and *P. strenuus* are well developed and morphologically identical to the ones found on the main host. Both combinations with Carabidae are an example of successful transmission of Laboulbeniales between unrelated hosts, i.e. from Staphylinidae to Carabidae. The success of such intergeneric transmissions largely depends from both host and habitat characteristics (De Kesel 1996). More long-term samplings are needed to find out whether the host-range of the *E. lathrobii* population from this ash-alder forest is changing from year to year, i.e. infecting more and other Carabidae or Staphylinidae.

Great care needs to be taken with the identification of thalli from the above mentioned three hosts. Besides single infections with *Euzodiomyces lathrobii*, *Rhadinomyces cristatus*, *Laboulbenia fasciculata*, *Laboulbenia kajanensis* or *Laboulbenia angutoris*, we regularly observed mixed infections, although never with more than two of these species.

• *Hesperomyces virescens* Thaxt.
Harmonia axyridis (Pallas, 1773) [Coccinellidae]: herbarium building, overwintering 2007, GC 177. More data given in De Kesel (2011).

• *Laboulbenia amoplogeni* Thaxt.
Stenolophus teutonus (Schrk., 1781) [Carabidae]: along a dirt road, 22.08.2006, ADK4703 (leg. Gerstmans C. - GC77).

• *Laboulbenia angutoris* Cepède & L. Picard*
Pterostichus strenuus (Panz., 1797) [Carabidae]: ash-alder forest, 08.04.1992, ADK650; ibid., 22.04.1992, ADK687; ibid., 01.07.1992, ADK688.

• *Laboulbenia benjaminii* Balazuc ex Balazuc*
Badister bullatus (Schrk., 1798) [Carabidae]: grassland, 03.06.1992, ADK697.

– *Badister lacertosus* Sturm, 1815 [Carabidae]: grassland, 01.07.1992, ADK698.

– *Badister sodalis* (Duft., 1812) [Carabidae]: grassland, 08.04.1992, ADK699; ash-alder forest 02.06.1993, ADK4684; ibid., 17.06.1993, ADK4702; ibid., 25.06.2009, ADK4725 (leg. Gerstmans C. - GC81).

• *Laboulbenia clivinalis* Thaxt.*
– *Clivina collaris* (Hbst., 1784) [Carabidae]: grassland, 22.04.1992, ADK701; ibid. 20.05.1992, ADK702; ash-alder forest, 23.09.1993, ADK4675; roadside, 19.04.2007, ADK4706 (leg. Gerstmans C. - GC69).

• *Laboulbenia collae* T. Majewski*
– *Agonum* [*Paranchus*] *albipes* (F., 1796) [Carabidae]: ash-alder forest, 01.07.1992, ADK695; 24.03.1992, ADK711; ibid., under a log, 04.08.2008, ADK4659.

• *Laboulbenia egens* Speg.
Tachys micros (Fisher von Waldheim, 1828) [Carabidae]: in a tuft of grass, between concrete stones (pavement), 30.06.2009, ADK4727 (leg. Gerstmans C. - GC100).

Laboulbenia egens was found in 1945 by A. Collart on a *Tachys parvulus* (Dejean, 1831) in Wavreille (De Kesel & Rammeloo 1992). The material consisted of young specimens with an immature perithecium. The new specimens were found on *T. micros*, a very small and rarely collected species in Flanders and Belgium. It is reported rare in the Red List of Flanders, critically endangered in Wallonia and endangered in Germany (Desender *et al.* 1995). The thalli are mature and leave no doubt about their identity. The base of the abaxial outer wall cells of the perithecium (second horizontal row) shows small but marked protuberances, cell IV and V have about the same height, and the septum IV-V is perpendicular to the top of cell III.

• *Laboulbenia elaphri* Speg.*
Elaphrus cupreus Duft., 1812 [Carabidae]: ash-alder forest, 29.07.1992, ADK710.
Elaphrus riparius (L., 1758) [Carabidae]: park, 10.05.1944, Collart L.237.

• *Laboulbenia cubradycelli* Huldén*

– *Bradycellus harpalinus* (Serv., 1821) [Carabidae]: ash-alder forest, 07.04.1993, ADK714.

– *Bradycellus verbasci* (Duft., 1812) [Carabidae]: ash-alder forest, 10.05.1992, ADK700.

• *Laboulbenia fasciculata* Peyr.*

Patrobus atrorufus (Ström., 1768) [Carabidae]: ash-alder forest, 22.04.1992, ADK689, ADK690; 09.09.1992, ADK691.

Pterostichus nigrita (Payk., 1790) [Carabidae]: ash-alder forest, 03.06.1992, ADK709; 07.04.1993, ADK713.

• *Laboulbenia flagellata* Peyr.*

Agonum assimile (Payk., 1790) [Carabidae]: ash-alder forest, 08.04.1992, ADK694; humid forest, under rotting log, 04.08.2008, ADK4655; grassland, 03.07.1993, ADK4689.

– *Agonum fuliginosum* (Panz., 1809) [Carabidae]: humid forest, under rotting log, 04.08.2008, ADK4656.

Agonum moestum (Duft., 1812) [Carabidae]: grassland, 03.07.1993, ADK4688.

Agonum nigrum Dej., 1828 [Carabidae]: ash-alder forest, 22.04.1992, ADK712.

• *Laboulbenia kajanensis* Huldén*

Pterostichus strenuus (Panz., 1797) [Carabidae]: ash-alder forest (edge), under a stone, 04.08.2008, ADK4657.

Laboulbenia kajanensis is a very rare species easily recognized by the dextro-rotated appendages and perithecium. It is only known from the type locality in Finland (Huldén 1983) and one locality in Poland (Majewski 1994a, Majewski 2008). The host, *Pterostichus strenuus*, is a rather common and eurytopic carabid beetle, occurring in a variety of dry to humid habitats (Desender *et al.* 1995). In the studied area it is mainly infected with *Laboulbenia argutoris* and *Euzodiomyces lathrobii*, for the latter species *P. strenuus* is an occasional host.

• *Laboulbenia leisti* J. Siemaszko & Siemaszko

Agonum muelleri (Hbst., 1784) [Carabidae] roadside, 22.08.2006, ADK4704 (leg. Gerstmans C. – GC76), 24.04.2007, ADK4707a,b (leg. Gerstmans C. – GC70); roadside, park, 11.08.2006, ADK4711a,b (leg. Gerstmans C. – GC73).

Laboulbenia leisti was first mentioned in Belgium (Lombardsijde, 11.1989, ADK360a,b) on *Leistus ferrugineus* (L.) (De Kesel, 1998), i.e. the usual host (Santamaria *et al.* 1991). The type originates from Poland. Our material corresponds best with the descriptions and illustrations given in Majewski (1994a). The occurrence on *Agonum muelleri* is remarkable and unique, since all *Leistus* ssp. captured in the Domain were free of Laboulbeniales. Based on the high prevalence and thallus density of *L. leisti* on *Agonum muelleri*, it is doubtful that this combination is occasional or fortuitous.

Scheloske (1969) mentions thalli on *Agonum* ssp. (especially *A. dorsale*) that strongly reminds *L. leisti* as well as *L. flagellata*. According to Scheloske (*l.c.*) there may be intermediate forms between these taxa. More material is needed; if Scheloske's (*l.c.*) hypothesis is correct, then the separate position of *L. leisti* becomes uncertain.

• *Laboulbenia notiophili* Cepede & F. Picard*

Notiophilus biguttatus (F., 1779) [Carabidae]: ash-alder forest, 03.04.1992, ADK703; park, dirt road next to a woodpile, 15.06.1993, ADK924, ADK930; deciduous forest, park, 07.08.2006, ADK4710 (leg. Gerstmans C. – GC75).

Notiophilus rufipes Curt., 1829 [Carabidae] ash-alder forest, 08.04.1992, ADK704.

• *Laboulbenia pseudomasei* Thaxt.*

Pterostichus anthracinus (Ill., 1798) [Carabidae] ash-alder forest, 22.04.1992, ADK705.

Pterostichus nigrita (Payk., 1790) [Carabidae] humid deciduous forest, 08.04.1992, ADK706, ADK707, ADK708; ash-alder forest, 25.06.2009, ADK4726 (leg. Gerstmans C. – GC82).

Velocia brevicollis (F., 1792) [Carabidae] humid deciduous forest, under rotting log, 04.08.2008, ADK4654.

Laboulbenia pseudomasei was found on *Velocia brevicollis*. It is usually reported on representatives from the genus *Pterostichus* (Pterostichini) (Santamaria *et al.* 1991, Majewski 1994a). The abundance of *L. pseudomasei* is relatively high in the area which may explain

the fortuitous infections of *Nebria* (Nebriini). From infection experiments, under controlled conditions, we know that *Nebria brevicollis* is a suitable host for other Laboulbeniales (De Kesel 1996).

• *Laboulbenia thaxteri* Cépède & F.Picard

Asaphidion flavipes (L., 1761) [Carabidae]: grassland, 06.05.1992, ADK696; dirt road next to an old woodpile, 24.06.1994, ADK887; ibid., 15.06.1993, ADK933.

• *Laboulbenia vulgaris* Peyr.

Bembidion properans (Steph., 1828) [Carabidae]: forest edge, 04.08.2008, ADK4658; dirt road, 27.07.2007, ADK4708 (leg. Gerstmans C. - GC72); ibid., 30.10.2006, ADK4709 (leg. Gerstmans C. - GC74).

Bembidion tetracolum (Say, 1823) (Ill., 1798) [Carabidae]: ash-alder forest, 25.06. 2009, ADK4724 (leg. Gerstmans C. - GC80)

• *Monoicomyces californicus* (Thaxt.) Thaxt.

Oxytelus (Anotylus) sculpturatus (Grav., 1806) [Staphylinidae], grassland, 18.05.1977, ADK397; ibid., 02.05.1992, ADK647.

• *Monoicomyces homalotae* Thaxt.*

Atheta sp. [Staphylinidae]: grassland, 24.02.1993, ADK653; ash-alder forest, 24.11.1993, ADK4676, ADK4677a,b,c; 24.03.1993, ADK4679, ADK4680; grassland, 24.03.1993, ADK4713, ADK4714.

• *Peyritschiella heinemanniana* De Kesel*

Xantholinus longiventris Heer, 1839 [Staphylinidae]: humid grassland, 15.06.1992, ADK648a,b; grasland, 05.05.1993, ADK4696; ash-alder forest, 19.05.1993, ADK4699; 17.06.1993, ADK4701

Peyritschiella heinemanniana was described from material found in sector 44 of the Domain, the type locality (De Kesel 1998b). Now twelve years later we know that infected hosts only occur in the most swampy parts of the alder forest and that they usually exhibit high thallus densities on the abdomen. *P. heinemanniana* is rare and so far also reported from Italy and Spain (Santamaria & Rossi 1999) where it infects *Leptolinus nothus* (Erichson), a staphylinid beetle not known from Belgium. Despite the different hosts and countries reported so far, all thalli are morphologically identical.

• *Peyritschiella protea* Thaxt.*

– *Anotylus rugosus* (F., 1775) [Staphylinidae]: ash-alder forest, 23.09.1993, ADK4681.

– *Philonthus* sp. [Staphylinidae]: ash-alder forest, 10.03.1993, ADK4678.

• *Phaulomyces simplocariae* De Kesel*

– *Simplocaria semistriata* (F., 1794) [Byrrhidae]: ash-alder forest, 20.04.1993, ADK4686.

Phaulomyces simplocariae is so far only reported from Belgium (De Kesel 1994). The thalli are very small and difficult to detect on the hairy integument of the host. The host, *S. semistriata* (Coleoptera, Byrrhidae), has a wide distribution ranging from temperate to subtropical regions (Freude *et al.* 1979). It is common in deciduous forests where adults and larvae feed on the rhizoïds of *Polytrichum* sp. and other mosses.

The type locality (Domain 'de Notelaer' near Bornem, Prov. Antwerp) is an old park near a tidal river (the Scheldt). The soil is alluvial, eutrophic and wet; the air humidity is relatively high throughout the year. The second locality are small dunes locked in the vast salt marshes of the coastal reserve 'het Zwin' (Knokke-Heist, Prov. West-Vlaanderen). Being also present in an ash-alder forest (the Domain of Bouchout), we conclude that both host and parasite must have a wide ecological amplitude. We think *P. simplocariae* may also be more common than first expected.

P. simplocariae is the only species reported from Byrrhidae, a host group rarely screened by laboulbenniologists. According to Benjamin (1989) all previous reports of Laboulbeniales on Byrrhidae, i.e. *Aporomyces* spp. and *Cantharomyces borderi* Picard, came from Limnichidae (Coleoptera) belonging to the genera *Limnichus*, *Byrrhinus* or *Pelochares*.

P. simplocariae is easy to recognize and morphologically close to *Phaulomyces octotemni* (Majewski) H.Tavares (= *Euphoromyces octotemni* Majewski), a species found on *Octotemnus* (Coleoptera, Cnidae). The thalli from *P. octotemni* are smaller and hyaline, they

have an asymmetrical peritheciun and the basal cells of the peritheciun are short.

• *Rhachomyces philonthinus* Thaxt.*
Philonthus varians (Payk., 1789) [Staphylinidae]: ash-alder forest, 23.09.1993, ADK4683; ibid., 02.06.1993, ADK4685; grassland, 03.07.1993, ADK4690, ADK4691.

• *Rhadinomyces cristatus* Thaxt.*
Lathrobium brunnipes (F., 1792) [Staphylinidae]: ash-alder forest, 23.09.1993, ADK4682.
Lathrobium elongatum (L., 1767) [Staphylinidae]: grassland, 05.05.1993, ADK4694a,b.

• *Symplectromyces vulgaris* (Thaxt.) Thaxt.*
Quedius fuliginosus (Grav., 1802) [Staphylinidae]: wet grassland, 02.05.1992, ADK646.
Quedius fumatus (Steph., 1833) [Staphylinidae]: grassland, 02.06.1992, ADK649.
Quedius sp. [Staphylinidae]: wet grassland, 24.02.1993, ADK652; wet deciduous forest, 02.06.1993, ADK1692; ash-alder forest, 20.04.1993, ADK4687a,b,c,d; 20.09.1993, ADK4697, ADK4698; grassland, 10.03.1993, ADK4717.

• *Teratomyces philonthi* Thaxt.*
Gabrius sp. [Staphylinidae]: ash-alder forest, 23.09.1993, ADK4674.

Conclusions

In Belgium 107 species of Laboulbeniales were recorded so far. The sampling efforts are far from evenly distributed, but along with the coastal nature reserve 'het Zwin' (Knokke-Heist, prov. West-Vlaanderen) and the valley of the Scheldt (between Bornem and Niel, Prov. Antwerpen), the Domain of Bouchout is one of the best study sites in the country. Although these 3 sites have benefitted a similar interest and in-depth investigation, the Domain of Bouchout is by far the richest site, hosting 34 species of Laboulbeniales, followed by the nature reserve 'het Zwin' with 19 species. Due to the abundance of halobiont taxa in the latter's coastal salt marshes and dunes, its species composition is fundamentally different and not comparable to any of the other sites we studied.

The most important host group for the Laboulbeniales from the Domain are Carabidae (55 species, 27 infected, belonging to 13 genera), followed by Staphylinidae (16 species infected, belonging to 11 genera), Byrrhidae (1), Catopidae (1), Coccinellidae (1), Nitidulidae (1) and Pselaphidae (1). On Carabidae 17 species of Laboulbeniales were found, belonging to just 2 genera (*Laboulbenia* and *Euzodiomyces*). On Staphylinidae 14 species of Laboulbeniales were found belonging to 10 different genera. Only *Euzodiomyces lathrobii* infects both Staphylinidae and Carabidae. The wide range of genera of Laboulbeniales found on Staphylinidae is explained by the diversity of Staphylinid genera and their widely divergent ecology (Frank 1982).

From the 34 Laboulbeniales recorded, none is unique to the Domain. Some species are rare because they are known from just a few localities worldwide, or because their host is very rare (*Laboulbenia egens* from *Iachys micros*). The Domain is the type locality of *Peyritschiella hememanniana*, and also one of the three localities for *Laboulbenia kajanensis* in the world. A large number of 'first record for Belgium' came from the Domain, and *Ophianandromyces audisioi* is, for the time being, the last one in the row.

Almost 95 % of the Laboulbeniales recorded in the Domain were caught in the ash-alder forest from sector 44. The pitfall trapping campaign yielded 25 species of Laboulbeniales and together with it a very precise view on the parasite-host community in this particular type of forest. Since most laboulbenitologists screen selections of host taxa, and not entire host communities, there are very few community data available for comparison. Only Scheloske (1969) and especially Majewski (1994b, 2003) studied entire communities from similar habitats. Their work is also based on intensive sampling campaigns over several years, but using next to pitfall traps, also other techniques to collect insects from litter, feces and carcasses of vertebrates. Both authors demonstrated that ash-alder forests are very rich in Laboulbeniales. Scheloske (1969) found 38 species in marshy alder forests, i.e. including the Laboulbeniales from the aquatic Coleoptera, which

strictly speaking do not belong to the forest dwelling Coleoptera. In Bialowieza (Poland), Majewski (1994b, 2003) found a staggering 52 species of Laboulbeniales in the Fraxino-Alnetum and 54 in the Carici elongatae-Alnetum. Our figures are significantly lower and this is due to the smaller surface of our ash-alder forest plot and the lack of suitable microhabitats for Laboulbeniales (feces and carcasses). The inventarisation is also still incomplete since a number of important host groups, like Diptera, still need to be sampled and screened.

Our data do show that the ash-alder forest of the Domain holds a number of rare and unique taxa and host-parasite combinations. The most novel combinations are *Laboulbenia pseudomasei* with *Nebria brevicollis* and *Pterostichus strenuus* with *Euzodiomyces lathrobii*. The study site seems particularly appropriate for spontaneous intergeneric transmission of a number of Laboulbeniales.

To get a better long-term view on the diversity and the structure of the parasite-host communities of Laboulbeniales in the ash-alder forest of sector 44, future sampling should be extended by including also Diptera, aquatic Coleoptera, aquatic Heteroptera and some particular Coleoptera from specific habitats. Collecting potential hosts in feces, dead wood, decaying plants, litter, carcasses and fruiting-bodies of fungi is important, because Laboulbeniales are more bound to these micro-habitats (selected by the host), than to the forest type (Majewski 2003). Supplemented with a new collecting effort of two years, we expect to find a fair number of new taxa for Belgium and possibly double the amount of Laboulbeniales recorded in the Domain.

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References

Benjamin R.K. (1971) – Introduction and supplement to Roland Thaxter's contribution towards a monograph of the Laboulbeniaceae. *Bibliotheca Mycol.* **30**: 1-155.

Benjamin R.K. (1989) – Taxonomy and morphology of Aporomyces (Laboulbeniales). *Aliso* **12**: 335-367.

Benjamin R.K. & Shanor L. (1951) – Morphology of immature stages of Euzodiomyces lathrobii Thaxter and the taxonomic position of the genus Euzodiomyces. *American Journal of Botany* **38**: 555-560.

Boeken M. (1987) – De loopkevers (Cicindelidae en Carabidae) van Nederland. Utrecht, Jeugdbondsuitgeverij.

Collart A. (1945) – A propos des Laboulbéniacées. *Bull. Mens. Naturalistes Belges* **26**: 98-103.

De Kesel A. (1994) – Phaulomyces simplocariae sp. nov. (Ascomycetes, Laboulbeniales) from Simplocaria semistriata (Coleoptera, Byrrhidae). *Mycotaxon* **50**: 191-198.

De Kesel A. (1995) – Population dynamics of Laboulbenia clivinalis Thaxter (Ascomycetes, Laboulbeniales) and sex-related thallus distribution its host Clivina fossor (Linnaeus, 1758) (Coleoptera, Carabidae). *Bulletin et Annales de la Societe Entomologique de Belgique* **131**: 335-348.

De Kesel A. (1996) – Host specificity and habitat preference of Laboulbenia slackensis. *Mycologia* **88 (4)**: 565-573.

De Kesel A. (1998a) – Identificatie en gastheerspectrum van het genus Laboulbenia in België (Ascomycetes, Laboulbeniales). *Sterbeeckia* **18**: 13-31.

De Kesel A. (1998b) – Peyritschiella heinemanniana sp. nov. (Ascomycetes, Laboulbeniales), a new ectoparasitic species Xantholinus longiventris (Coleoptera, Staphylinidae). *Belgian Journal of Botany* **131**: 176-180.

De Kesel A. (2002) – Het genus Rhachomyces (Ascomycetes, Laboulbeniales) in België. *Sterbeeckia* **21/22**: 74-84.

De Kesel A. (2004) – Monoicomyces (Ascomycetes, Laboulbeniales) in Belgium. *Sterbeeckia* **25**: 62-72.

De Kesel A. (2011) – Hesperomyces (Laboulbeniales) and Coccinellid hosts. *Sterbeeckia* **30**: 32-37.

De Kesel A. & Haghebaert G. (1991) – Laboulbeniales (Ascomycetes) of Belgian Staphylinidae (Coleoptera). *Bulletin et Annales de la Societe Entomologique de Belgique* **127**: 253-270.

De Kesel A. & Rammeloo J. (1992) – Checklist of the Laboulbeniales (Ascomycetes) of Belgium. *Belgian Journal of Botany* **124 (2)**: 204-214 [1991].

De Kesel A. & Krastina-De Kesel I. (2006) – Laboulbeniales (Ascomycetes) from Latvia. *Acta Mycologica* **41**: 55-64.

Desender K. (1995) – Carabidae. *In: Enumeratio Coleopterorum Belgicae* **1**. Ed. G. Coulon. Societe royale belge d'Entomologie: 13-28.

Desender K., Maes D., Maelfait J.-P. & Van Kerckvoorde M. (1995) – Een gedocumenteerde Rode Lijst van de zandloopkevers en loopkevers van Vlaanderen. *Mededel. Inst. Natuurbehoud* **1**. Brussel: 1-8.

Drugmand D. (1996) – Atlas des Staphylinus de Belgique et du Grand Duché de Luxembourg (Coleoptera Staphylinidae Staphylininae). *Mem. Soc. r. belge Ent.* **36**: 1-194.

Frank J.H. (1982) – The parasites of the Staphylinidae (Coleoptera). *Bulletin. Florida Agricultural Experiment Stations* **824**: 1-118.

Freude H., Harde K.W. & Lohse G.A. (1979) Die Käfer Mitteleuropas. Bd. 6. Krefeld (Germany), Goecke & Evers Verlag.

Huldén L. (1983) Laboulbeniales (Ascomycetes) of Finland and adjacent parts of the U.S.S.R. *Karstenia* **23**: 31-136.

Kirk P.M., Cannon P.F., Minter D.W. & Stalpers J.A. (2008) Ainsworth & Bisby's Dictionary of the Fungi, 10th Edition. CAB International. Wallingford Oxon, UK.

Lohse G. (1964) Staphylinidae I (Micropeplinae bis Tachyporinae). *In* Freude H., Harde K.W. & Lohse G.A., Die Käfer Mitteleuropas IV. Krefeld (Germany), Goecke & Evers.

Lohse G., Benick G. & Likowski Z. (1974) Staphylinidae II (Hypocyphtinae und Aleocharinae). Pselaphidae. In Freude H., Harde K.W. & Lohse G.A., Die Käfer Mitteleuropas V. Krefeld (Germany), Goecke & Evers.

Majewski T. (1994a) The Laboulbeniales of Poland. *Polish Botanical Studies* **7**: 1-466.

Majewski T. (1994b) The occurence of the Laboulbeniales (Fungi, Ascomycetes) in natural forest communities in the Bialowieza. *Fragmenta Floristica et Geobotanica* **39**: 479-501.

Majewski T. (2003) Distribution and ecology of Laboulbeniales in the Bialowieza Forest and its western foreland. *Phytocoenosis* **15** (n.s.) *Supplementum Cartographiae Geobotanicae* **16**: 1-144.

Majewski T. (2008) Atlas of the geographical distribution of fungi in Poland. Fasc. 4. Laboulbeniales. W. Szafer Institute of Botany, Polish Academy of Sciences, Krakow, Poland.

Markovskaja S. (2000) Data on Lithuanian Laboulbeniales. *Botanica Lithuanica* **6**: 299-311.

Rossi W. (1982) Aphanandromyces, a new genus of Laboulbeniales (Ascomycetes). *Mycologia* **74**: 520-523.

Santamaria S. (1998) Flora Mycologia Iberica. Vol. 4. Laboulbeniales, I. Laboulbenia. Madrid, Real Jardin Botanico Madrid & J. Cramer.

Santamaría S. (2003) Flora Mycologia Iberica. Vol. 5. Laboulbeniales, II. Acompsomyces-Hyomyces. Madrid, Real Jardin Botanico Madrid & J. Cramer.

Santamaría S., Balazuc J. & Tavares I.I. (1991) Distribution of the European Laboulbeniales (Fungi, Ascomycotina). An Annotated List of Species. *Inst. Bot. Barcelona* **XIV**: 1-123.

Santamaría S. & Rossi W. (1999) New or interesting Laboulbeniales (Ascomycota) from the Mediterranean region. *Plant Biosystems* **133**: 163-171.

Scheloske H.W. (1969) Beitrage zur Biologie, Ökologie und Systematik der Laboulbeniales (Ascomycetes) unter besonderer Berucksichtigung des Parasit-Wirt-Verhaltnisses. *Parasitol. Schriftenreihe* **19**: 1-176.

Segers R. (1986) Catalogus Staphylinidarum Belgicae (Coleoptera). *Studiedocumenten Kon. Belg. Inst. Natuurwet.* **32**. Brussel, K.B.I.N.

Sugiyama K. (1973) Species and genera of the Laboulbeniales (Ascomycetes) in Japan. Tokyo, Academia Scientific Book Inc.

Tavares I.I. (1985) Laboulbeniales (Fungi, Ascomycetes). *Mycologia Memoir* **9**: 1-627.

Weir A. (1996) A preliminary host-parasite list of British Laboulbeniales (Fungi, Ascomycotina). *The Entomologist* **115**: 50-58.

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Red List ectomycorrhizal fungi and their dependence on park management

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Résumé. – Liste rouge des champignons ectomycorhiziens du Jardin botanique et leur dépendance sur la gestion du Domaine. Dans le Domaine du Jardin botanique national, plus de 200 espèces de champignons ectomycorhiziens ont été trouvées durant la période 1989-2008, dont 52 espèces de la Liste Rouge. Nous décrivons leur répartition et expliquons leur présence sur base des différents modes de gestion. Dans les parcelles boisées non gérées, sous les arbres à feuilles riches en nutriments, les vers de terre améliorent la disponibilité des substances minérales. Ici, une seule espèce de la Liste Rouge a été trouvée. Sous les arbres à feuilles pauvres en nutriments, les vers de terre qui creusent profondément sont quasiment absents et une épaisse litière de feuilles mortes couvre le sol. La présence de mycorhizes y est élevée mais le nombre d'espèces mycorhiziennes y est faible, peut-être en raison d'un nombre de niches restreint. On y trouve également qu'une seule espèce de la Liste Rouge. Sous les arbres où les feuilles mortes sont enlevées et où la végétation est maintenue courte, les nutriments sont exportés et le sol s'assèche facilement, ce qui fait que les vers de terre peuvent être rarissimes. Sous ces conditions de stress, l'arbre ne forme pas de poils absorbants mais développe une symbiose avec les champignons ectomycorhiziens. Ici, 51 espèces de la Liste Rouge ont été observées.

Samenvatting. – Rode Lijst van de ectomycorrhizapaddenstoelen van de Plantentuin en hun afhankelijkheid van het gevoerde parkbeheer. In het Domein van de Nationale Plantentuin werden in 1989-2008 ruim 200 soorten ectomycorrhizapaddenstoelen aangetroffen, inclusief 52 Rode-Lijstsoorten. We beschrijven hun verspreiding en verklaren hun voorkomen op basis van de diverse beheersvormen. In niet beheerde bosgedeelten verbeteren regenwormen onder bomen met voedselrijk blad de beschikbaarheid van de mineralen. Hier is slechts 1 Rode-Lijstsoort aangetroffen. Onder bomen met voedselarm blad ontbreken diepgravende regenwormen en ontstaat een dikke strooisellaag. De bezetting met mycorrhiza is er hoog, maar het aantal soorten is er laag, wellicht door een gering aantal niches. Ook hier is slechts 1 Rode-Lijstsoort gevonden. Onder bomen waar blad wordt geruimd en de vegetatie kort gehouden, worden voedingsstoffen afgevoerd en droogt de bodem gemakkelijk uit, waardoor regenwormen kunnen ontbreken. Onder deze stressomstandigheden vormt de boom geen wortelharen, maar gaat een symbiose aan met ectomycorrhizaschimmels. Hier werden 51 Rode-Lijstsoorten aangetroffen.

Introduction

Just like various other groups of organisms, fungi have declined in Belgium. That decline of the mycoflora is strongest among the ectomycorrhizal fungi (EM fungi) (Arnolds & Jansen 1992, Walleyn & Verbeken 2000). Many species that used to occur in woods are now restricted to poor patches in avenues, alleys and (managed) parks (Walleyn & Verbeken 2000). According to Arnolds & van Ommering (1996) the main cause is the deposition of nitrogen.

Other environmental factors such as acidification and desiccation are also important. Apart from these, other natural causes and changed forest management practices hardly receive any attention when the decline of ectomycorrhizal fungi in woods is being discussed.

Both latter factors are closely linked. Today, trees are allowed to grow older than formerly. Previously, only part of the trees were felled. It follows that today in (older) woods processes occur that we hardly knew before. The changes in forest management since the 20th century are strongly underestimated as a cause of the decline of ectomycorrhizal fungi, possibly because of the poor knowledge of this subject among mycologists. During the first half of the 20th century the standard deciduous forest consisted of rows of pruned trees, often separated by ditches. Shrubs were usually missing. The 'standard deciduous forest' looked like a collection of parallel alleys. In the Campine, humus was gathered from the pine forests. A source from 1888 mentioned by Burny (1999) estimated that the total weight of dry needles collected there each year was almost 3,000 kg per hectare.

Large parts of the Domain of the Botanic Garden have been intensively managed for decades (removal of leaves and frequent mowing). There is a striking contrast between the managed areas, which teem with EM fungi (including many Red List species), and the relatively undisturbed wooded areas, which are extremely poor in EM fungi.

Because of the great number of species of fungi and the poor knowledge of their distribution, the Flemish Red List (Walleyn & Verbeken 2000) only deals with a selection of 552 species, including 320 EM fungi.

In this contribution we give a survey of the EM fungi in the Domain that are mentioned in the Red List. We study their distribution and their relation to park management. We furthermore explain their abundance in the managed areas and their seeming absence in the relatively undisturbed wooded zones, this is elucidated by describing natural processes.

Ectomycorrhizal fungi

About 4,000 species of macrofungi occur in Flanders. Based on the role they play in various ecosystems they can be divided into three groups: parasites (that extract their food from living organisms), saprophytes (that break down dead organic material) and ectomycorrhizal fungi (that live in symbiosis with plants, usually trees).

EM fungi form a mantle of hyphal threads on the thinner roots of the tree. The tree does not make root hairs on the roots covered with ectomycorrhiza. From the mantles hyphal threads grow into the soil. By living in symbiosis rather than forming root hairs the tree can acquire nutrients and water in a more efficient way. In an equal amount of soil, at least 100 times the amount of plant material as compared with fungi is needed for that (Harley *in* Kuyper *et al.* 1990). Ectomycorrhiza also offers better protection against heavy metals and aluminium, and against pathogens (Harley & Smith *in* Kuyper *et al.* 1990). In exchange the fungus receives sugars from the tree. This can amount to 20 % of the total amount made by the tree, which is a high price. EM fungi are therefore not primarily important to stimulate a tree's above ground production, but rather to help trees survive unfavourable circumstances or 'stress' (Kuyper *et al.* 1990). Areas where trees grow poorly may be very rich in EM fungi. Examples are dry (sandy) soils where minerals easily seep through, wet peaty soils that are rich in nutrients but where it is difficult for shallow-rooted trees to reach these nutrients, and especially shallow, easily dehydrating stony (calcareous) soils, which often lack nitrogen and phosphate. In healthy woods EM fungi are often rare. They occur with most deciduous and coniferous trees, but for instance not with ash (*Fraxinus*), maple (*Acer*), elm (*Ulmus*), horse chestnut (*Aesculus*) and plane (*Platanus*).

History and management

The Domain of the Botanic Garden consists of (parts of) two historical castle estates. Its history and land use are briefly described by

Ronse & Vidts (2011). During a period of great restoration (1832) an English-style park was laid out around the castle. The wooded areas were then planted chiefly with beech (*Fagus*) and to a smaller degree oak (*Quercus*) and chestnut (*Castanea*). Rows of trees, groups of trees and isolated trees were mainly beech and chestnut. Oak and lime (*Tilia*) were less numerous, together with species that do not form ectomycorrhiza, such as plane, ash and tulip tree (*Liriodendron*). Some of these trees are still present today.

About 1880 a forest belt of chestnut and maple, with some lime and beech, was planted around the Domain, and small woodland patches were created with grey poplar (*Populus* × *canescens*) or a mixture of chestnut and maple. Isolated trees, mainly oak, were rare.

From 1939 onwards the Belgian state became owner of the Domain. Collections had to be transferred from the Botanic Garden in Brussels. The lawns were renewed, and till 1981 they were strongly fertilized on a regular basis, and the mown grass was removed (communication M. Verhaegen).

In the wooded areas management has always been limited to the removal of fallen and 'dangerous' trees. Until the early 1980s, each year the leaves were removed in at least 12 wooded areas and also along the fringes and roadsides in the forest to about 3 m into the woodland. Today this is continued in 3 zones only. Elsewhere the leaves are blown into the fringe of the wood. This is harmful to beech (the most important mycorrhizal tree in the Domain), because beech does not regenerate in a thick layer of humus. Under the trees the lawns are mown and leaves are removed, formerly the first mowing took place there in April, but since about 1995 that has been postponed till the second half of June.

Data and data processing

Beginning in 1989, data on casual observations were recorded from all over the Domain. Since 1996 a fixed route covering all the richest places for mycorrhizal fungi was walked once or twice a week, from the moment the first boletes appear until the first night frost in November. Initially only boletes (Boletaceae) were recorded, but since 2006 the other mycorrhizal fungi have also been entered. Since 2003 the sites of the individual fungi have been carefully measured and mapped (scale 1/100). The other parts of the Domain are surveyed too, but on an irregular basis only. Some observations were made by A. De Kesel and R. Walleyn. Data from other observers have not been taken into consideration, as the location of sites was not accurate enough. Moreover, these observers have not seen any additional Red List species.

The records basically come from different locations (mycelia), but this can be confirmed only by molecular research. Therefore we divided the various habitats into areas. Each area was carefully screened for Red List species. Figure 1 shows the number of Red List fungi for each zone. For each location it was recorded whether the fungi were found inside or outside woodland, with further notes on the type of local woodland management (see the list of species in table 1).

Species richness

Well over 200 of approximately 700 EM fungi known in Flanders have been found in the Domain during the last 20 years (excluding, however, some not yet identified *Hebeloma* and *Cortinarius*). Measured by Flemish standards, the Domain is especially rich in Boletaceae and *Amanita* (table 2), but *Russula*, *Lactarius* and *Inocybe* also score well. *Inocybe* is not mentioned in the Red List; 42 out of 107 species found in Flanders (39.3%) have also been recorded from the Domain.

320 ectomycorrhiza formers are listed in the Red List. 216 species are more or less threatened, and of these 52 have been observed in the Botanic Garden (table 1). Within the Domain we have mapped 56 areas where Red List species occur (fig. 1). In three areas more than ten such species have been found. The highest number, 16 species, occurs in a piece of wood where the leaves are removed. Most Red List species in the Domain belong to the Boletaceae and *Russula* (table 2). In proportion

Species	Cat	Inside woodland			Outside woodland		Total
		Nev	1981	Alw	1981	Alw	
Leccinum crocipodium	1		1				1
Russula laeta	1					2	2
Tricholoma acerbum	1			1			1
Amanita franchetii	2			1			5
Amanita strobiliformis	2		2	1		7	10
Boletus queletii	2		3	1		11	15
Cantharellus ferruginascens	2		1	2		3	6
Gyrodon lividus	2	1					1
Gyroporus castaneus	2		1				1
Lactarius decipiens	2			1		6	7
Leccinum carpini	2		1	1		2	4
Leccinum duriusculum	2				1	1	2
Russula laurocerasi	2			1			1
Russula veternosa	2			2	1	1	4
Russula vinosopurpurea	2					2	2
Suillus granulatus	2					1	1
Tricholoma saponaceum	2			1		1	2
Boletus aereus	3					1	1
Boletus appendiculatus	3		2	1		9	12
Boletus impolitus	3					1	1
Boletus luridus	3		3	1	1	17	22
Boletus reticulatus	3		2	2		4	8
Boletus satanas	3		1				1
Boletus pseudoregius	3			1			1
Chalciporus rubinus	3					1	1
Hydnum repandum	3					1	1
Lactarius fulvissimus	3					2	2
Lactarius ruginosus	3					2	2
Russula carpini	3					2	2
Russula cuprea	3			2			2
Russula curtipes	3					1	1
Russula melliolens	3					3	3
Russula odorata	3					2	2
Russula pseudointegra	3	1	1				2
Russula puellula	3			1		2	3
Russula rhodella	3					1	1
Russula solaris	3			1		1	2
Russula sororia	3					1	1
Tricholoma album	3		1				1
Lactarius subsericatus	Z		1		1	2	4
Russula clariana	Z			1			1
Russula melzeri	Z					2	2
Boletus radicans	B		5	2		10	17
Lactarius deliciosus	B					1	1
Lactarius fluens	B				1	4	5
Lactarius pallidus	B				1		1
Russula acrifolia	B					1	1
Russula anthracina	B					1	1
Russula grisea	B					3	3
Russula insignis	B					1	1
Lactarius vellereus	A		1				1
Russula foetens	A				1	4	5
Number of sectors		2	10	3	1	38	56
Number of species		2	15	19	7	39	52

Table 1. The Red List ectomycorrhizal fungi recorded from the Botanic Garden, with indication of the number of zones where they have been observed.

Legend:

Cat. Red List category.
Nev. sectors which were never actively managed.
1981. sectors actively managed until at least 1981.
Alw. uninterrupted management since at least several decades.

Red List categories:
1. threatened with extinction.
2. threatened.
3. vulnerable.
Z. rare.
B. probably threatened.
A. decreasing.

Table 2. Survey of the ectomycorrhizal groups occurring in the Domain of the Botanic Garden and treated in the Flemish Red List. Legend: **RL**, Red List; **FL**, Flanders; **D**, Domain of the Botanic Garden; **D/FL**, relation Domain/Flanders (percentage).

	Boletaceae	*Russula*	*Lactarius*	*Tricholoma*	*Amanita*	*Cantharellus*	*Hydnum*	Total
Flanders	58	122	56	31	18	5	2	292
Domain	34	50	22	7	10	1	1	125
D/Fl	58,6	41,0	39,3	22,6	55,6	20,0	50,0	42,8
RL-Fl	27	75	34	24	9	5	2	176
RL-D	16	21	8	3	2	1	1	52
D/Fl	59,3	28,0	23,5	12,5	22,2	20,0	50,0	29,5

to Flanders the Domain has many Boletaceae (59.3%), with *Russula* being a good second, but the *Tricholoma* are disappointing. Of the genera treated in the Red List the Domain lacks *Hygrophorus*, *Gomphidius*, *Hydnellum*, *Phellodon* and *Sarcodon*. These fungi are mainly restricted to woods with a thin layer of humus.

It is difficult to compare the Botanic Garden with other parks. However, a study of the provincial domain d'Ursel in Hingene (30 ha) yielded 50 EM species, 8 of which are Red List species (De Kesel 2001).

The Red List gives an overview of the richest IFBL 4×4 km squares, the so-called 'hot spots'. Although few Red List saprophytes occur in it, the Domain is situated in the IFBL square with the highest score, namely 59 species. The one but richest square (with 49 species) includes the well-surveyed Zoerselbos. On number three is a square with 38 species that comprises part of the Sonian Forest, with numerous historical records. On number four is a square with 34 Red List species and numerous historical data from Tervuren Park.

Figure 1. Location of the zones in the Botanic Garden where Red List ectomycorrhizal fungi have been observed, with indication of the number of species recorded from each zone.

Relation with management

The unusual abundance of EM fungi in the Domain is found especially outside the woodland zones: along woodland fringes, under groups of trees, along rows of trees and under isolated trees (fig. 1). Thirty-nine out of 52 Red List species were recorded from 38 areas where the vegetation is kept short by frequent mowing and leaves are removed (table 1). In wooded areas Red List fungi mainly occur in the three zones where today leaves are still being cleared. Other woodland locations with records of EM fungi have been managed until at least 1981. In most of these, however, EM fungi have since disappeared. The most endangered species, such as *Leccinum crocipodium* (last observed in 1994) and *Boletus queletii* (last observed in 1996 but still present in a managed area), disappear within 15 years once the removal of leaves has been ended. Next to disappear are the somewhat less critical species, such as *Boletus appendiculatus* and *B. luridus*, and finally (after about 25 years) *Boletus radicans*. Meanwhile, commoner species such as *Xerocomus chrysenteron*, *X. communis* and *X. porosporus*, manage to settle. (In the above list we confined ourselves to the Boletaceae, because these are best documented.)

Once regular lawn management is stopped and the grass is mown only once a year (at the end of August, with removal of the cut grass), the decline of EM fungi goes much faster. The most critical species disappear within 5 years (Van de Kerckhove 2006). This is caused by an increased activity of earthworms, and this again results from the soil drying out badly under tall vegetation (see further).

The only Red List species that occurs in unattended woods is *Gyrodon lividus*. This species lives in alder-carr, a rare habitat within the Domain.

The healthy woodland soil

On nutrient-rich soil trees can grow that require nutrients for their foliage, sprigs, branches and trunk. Rich humus on wet soil is the ideal environment for earthworms that require a lot of (nitrogenous) food and a sufficiently humid soil. Wherever such conditions are met, earthworms may be numerous, creating a 'healthy' soil (mull).

In the Domain mull is found where trees produce rich humus; these trees include lime, grey poplar, hornbeam, chestnut, ash, elm and wild cherry (*Prunus avium*); see figure 2. The last three species do not form ectomycorrhiza. EM fungi are sparse in areas dominated by these trees. This we can also establish by watching the spring flora. Especially areas covered with ramsons (*Allium ursinum*) or wood anemone (*Anemone nemorosa*), or patches with lords-and-ladies (*Arum maculatum*), moschatel (*Adoxa moschatellina*) and other species typical of a layer of well-digesting humus are extremely poor in EM fungi and more specifically Red List species. Soil pH varies there between 6 and 7.3.

Deep burrowing earthworms play a vital role in 'healthy' woodland soil. They dig vertically and live on humus. Sometimes they are observed while eating on the surface, but usually they draw leaves and other plant debris, or dung, into the soil, where they (partly) eat that material. Where they are abundant, all the humus may already be drawn into the soil by the summer, the surface is then bare.

Deep burrowing earthworms also feed while digging and then eat the earth with all particles up to about 2 mm. Their excrements are deposited on the surface. Research in the U.S. has shown that the small heaps of excrement contain 5 times more nitrogen, 7 times more phosphate and 11 times more potassium than the earth surrounding them (http://nl.wikipedia.org/wiki/Regenworm, accessed July 2009).

Thanks to their burrowing and feeding, earthworms create crumbly and oxygen-rich soil, which retains moisture and minerals. Such soils are extremely rich in aerobic bacteria, so that mineralization occurs fast. Earthworms extract nutrients from organic material. With enzymes they can, just like fungi, release bound phosphates.

Minerals (nutrients) that despite the qualities of mull wash down are again made available for plants by earthworms that deposit

Figure 2. Temporal leaf breakdown in several tree species on mull and mormoder. Experiment conducted in the Domain of the Botanic Garden beginning in November 2004. The figures indicate the duration in years. The text letter of the name of the tree indicates when leaves had completely decomposed. The leaves of the different trees were pressed between layers of gauze and covered with humus. Therefore, on mull earthworms could not draw the leaf into the soil, that is why decomposition is probably faster under natural circumstances than shown in the diagram. On mull, nutrient-rich foliage completely breaks down in less than a year. Decomposition of nutrient-poor foliage takes more than a year. On mormoder breakdown takes twice as long: after 4.5 years leaves of beech and maple had only half decomposed, and foliage of willow (Salix) had not yet completely decayed either.

their excrements on the surface. When minerals (slowly) sink into the soil, they can be absorbed by root hairs. Areas with rich, more or less permanently moist soil may abound with earthworms. Each year they can bring more than 70,000 kg of excrements per hectare to the surface. There they burrow to a depth of 2.5 m and therefore trees can form root hairs just as deep. This makes it easier for a tree to get nutrients and renders symbiosis with mycorrhizal fungi superfluous.

Strong earthworm activity is detrimental to the mycoflora. Most EM fungi hardly withstand soil disturbance. The fine hyphal threads that from the mantle grow into the soil are extremely vulnerable. In the Botanic Garden I have never seen a single mycorrhizal fungus in areas with the highest earthworm activity. From zones with fewer earthworms I only recorded widespread species, particularly *Laccaria laccata*, *Paxillus involutus* and species of the genera *Hebeloma* and *Xerocomus*. Several different *Inocybe* too are able to form fungi where earthworm activity is high.

The only Red List species recorded from an unmanaged area with mull is *Gyrodon lividus*.

Thick layers of humus

When a thick layer of humus is present only few species of EM fungi are found. Thick layers arise under conifers and under trees with leaves that have little food value (e.g. oak or beech). Deep digging earthworms do not like poor humus, while they need a lot of food. On moist and nutrient-rich soil in the Botanic Garden we find a thick layer of humus (mormoder) only under beech (sometimes mixed with oak or chestnut), these plantations go back to the 1830s. In the Domain three samples under mormoder had a pH of respectively 4.4, 4.7 and 5.0.

Poor humus is mainly broken down by fungi and, to a lesser degree, by epigeic earthworms and other small soil fauna, including mites, springtails, insect larvae and millipedes. The decomposition of humus takes place on top of the mineral soil. Leaves of oak and beech may remain intact for more than a year. When it rains, they protect the underlying layers, in

which fungi and small soil animals are active, against compaction. In these well aerated layers the tree forms numerous thin roots. Deeper underground the soil is more compact due to a lack of earthworms, and therefore the trees are shallow rooted.

When poor humus decomposes, tannins are released, and acidification is intensified while the fungi secrete oxalic acid. As a result, the soil fauna declines and decomposition slows down. This again increases the dominance of fungi and leads to a more acid soil. In the long run the layer of humus grows thicker as the forest grows older. In the Netherlands thick layers of around 30 cm have been described, but in old Scandinavian forests they grow even thicker (Hommel *et al.* 2007). This is due to the fact that most organisms that cause decomposition and mineralization require a minimum temperature of ca. 10°C to be active. And, furthermore, old woodland in Scandinavia is often older than ancient woodland in Western Europe.

Owing to their acidification effect, trees can make life difficult for the ground fauna (which needs a nutritious substrate) and affect the growth of other plants. As a result, they are able to recycle the nutritious elements released from their fallen leaves.

Thanks to the slow decomposition trees probably have nutrients available during the whole growing season. We were rather surprised to find that the amount of EM fungi on the thin roots under the thick layers of humus is fairly to extremely high in the Domain. This applies both to old and new mycorrhizal mantles. Mycorrhizal fungi are important here probably because, as deep burrowing earthworms are absent, minerals can seep through more easily. The number of species is, however, small. Especially *Russula undulata*, *R. fellea*, *Amanita evelsa*, *Scleroderma citrina*, *Xerocomus communis* and *X. prunatus* should be mentioned here. Only the last species is uncommon in Flanders; it is only found under beech. It is striking that these fungi, living under a thick layer of humus, only emerge in very favourable years, possibly only when weather conditions are exceptional (prolonged rains) and sufficient water reaches the mycorrhizal fungi to stimulate the formation of fruit bodies.

The only Red List species that has been found in an unattended area with mormoder is *Russula pseudointegra*.

Situations in which ectomycorrhizal fungi are very important

In the Domain an interesting EM flora only occurs in patches that easily dry up in dry weather, where the activity of earthworms is limited or lacking (Van de Kerckhove 2006).

Due to the absence of earthworms the soil gets denser and becomes more anaerobic causing the trees to develop a shallow rooting system. Bacteria responsible for mineralization require a water film to move. They may be absent in very dry conditions. With their hyphal threads fungi can bridge air pores and cause decomposition and mineralization in dry places, although much slower than where earthworms and aerobic bacteria are numerous (table 3). If we remove leaves, we rob the tree of potential nutriment and cause the soil to dry up more easily. This may also happen in natural situations, for instance where (micro) relief prevents leaves from decomposing where they fall, or

Table 3. Changes in soil dampness and related presence of earthworms and aerobic bacteria, and degree of breakdown and mineralization.

Soil	Dry	Humid	Wet
Rainworms and aerobic bacteria	Absent	Numerous	Absent
Decomposition and mineralization	Slow (mainly by fungi)	Rapid (mainly by earthworms and aerobic bacteria)	Slow (mainly by microorganisms, e.g. anaerobic bacteria and fungi)

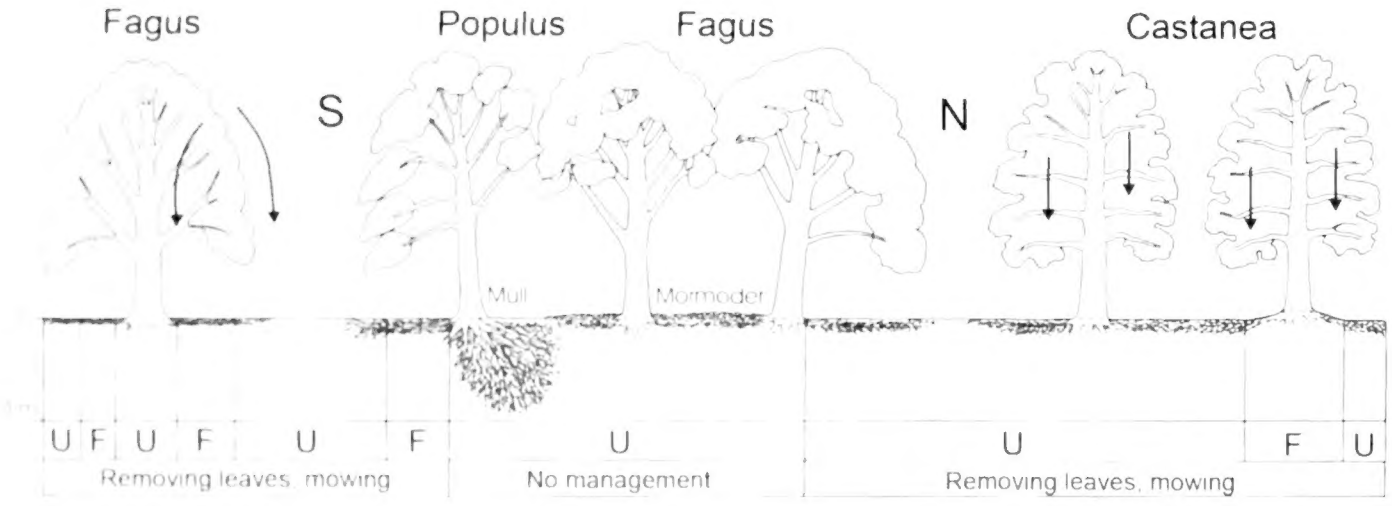

Figure 3. Favourable and unfavourable situations for Red List species in the Domain. U: unfavourable; F: favourable; S: south; N: north

in open habitats (such as heath and parkland) where leaves are easily blown away. Where earthworms are absent the (scarce) minerals can seep through. Under such stressful circumstances the tree does not form root hairs, but instead enters into symbiosis with mycorrhizal fungi (see above, 'Ectomycorrhizal fungi'). EM fungi can store minerals in their mantles and release these to the tree whenever it needs them. They are mostly found in the upper 5 to 10 cm of the soil (Baar & Ozinga 2007), probably because trees root superficially in dry conditions.

In the Domain the driest areas lie under trees about 175 years old. These transpire more water than younger ones, especially if they grow along the southern fringe of the wood or – in case of solitary trees or rows of trees – in sunny spaces. Under these trees frequent mowing (in open areas in the Garden already from April onwards) is important, so that the soil dries out more easily.

In quite some places, however, the soil does not dry up easily, and there we only find some banal species of the genera *Hebeloma*, *Laccaria*, *Inocybe* and *Xerocomus*. We may note here that these fungi are often considered pioneers, but in fact they are typical for moist patches with a fairly heavy earthworm activity.

Dry patches mostly occur under beech, a tree with relatively dense foliage. A lot of rainwater flows off via the crown. Water seeping through the crown is mainly transported along the slanting branches and the trunk (fig. 3). Similar results of throughfall water under beech have been reported by Staelens *et al.* (2006). Owing to this, the soil is dampest near the trunk and under the edge of the crown, and that is where we chiefly find species of the genera *Lactarius*, *Laccaria*, *Cortinarius*, *Inocybe* and *Xerocomus*. In the intermediate drier zone we mainly see the genera *Boletus*, *Russula* and *Amanita*. Many of these fungi are rare in Flanders and are mentioned in the Red List, such as *Boletus aereus*, *B. appendiculatus*, *B. queletii*, *B. reticulatus*, *Russula curtipes*, *R. laeta*, *R. melliolens*, *R. puellula*, *R. solaris*, *R. veternosa*, *R. vinosopurpurea*, *Amanita franchetii* and *A. strobiliformis*.

Oak and chestnut have a thin crown and horizontal branches. Rainwater easily gets through the crown and drips down the branches, so that often bare patches are formed (fig. 3). Where that is the case the ground is frequently covered with lesser celandine (*Ranunculus ficaria*) in springtime. In such moist areas we seldom find EM fungi in summer and autumn. Closer to the trunk the soil is somewhat drier and there some (common) EM fungi can be noted. In the Domain special fungi grow under oak, chestnut and lime solely in patches with microrelief, often near the base of the trunk. There rainwater can flow away more easily (fig. 3). In the Domain fungi thrive under oak only where the tree grows close to beech, so that the mycoflora can share in the benefits of the easily drying soil under beech.

Removing leaves and regular mowing: how 'natural' is such management?

Many Red List species in the Botanic Garden are strongly dependent on the removal of leaves and regular mowing. That doesn't seem very natural, does it?

The unusual ectomycorrhizal flora of the Domain mostly consists of species typical of (grassy) parkland with old trees. They appear under trees that are over 100 years old, growing among poor, grassy (mossy) vegetation. Characteristic of this habitat is the genus *Boletus*. *Russula* and *Inocybe* also grow here in large numbers. There are few woodland species in the Domain. Woods are only rich in EM fungi when at most a thin layer of humus is present. Typical forest fungi are mainly found among the genera *Tricholoma*, *Hygrophorus*, *Gomphidius*, *Cortinarius*, *Lactarius*, *Cantharellus*, *Hydnellum*, *Phellodon* and *Sarcodon*. These fungi, except for *Lactarius*, occasionally occur in the Domain (see above, 'Species richness').

Under natural circumstances parkland is not found in Europe anymore. Such landscape can however develop where domesticated cattle are present, as for instance in Romania or (closer to home) in the New Forest in southern England. According to Vera (1997) parkland dominated the original landscape in Western and Central Europe. For the creation of such parkland it is essential that old areas of woodland can degrade into grassland or heath. That seems only possible where oak and beech naturally occur in large numbers and in particular where they grow on dry ground. They make the soil very acidic. When the pH is lower than 5.5, plants living under such trees may be poisoned as a result of the absorption of harmful materials (such as aluminium), whereas the tree itself enjoys higher protection by EM fungi. After a very long time the soil becomes strongly degraded and under the pressure of cattle an open landscape with scattered old beeches and oaks can arise. Leaves are easily blown away and the thick layer of humus is gradually replaced with poor, grassy vegetation. Especially *Boletus* settles here, but also for instance *Russula* species. Such conditions exist – under artificial circumstances – in the Domain. When such natural development continues, even the last trees finally die and only (calcareous) grassland or heath remains.

Necessity for cultivation and continued management

The Domain is extremely rich in mycorrhizal fungi. But how long will that last? The old trees (ca. 175 years old) will slowly disappear. The patches with the greatest variety of species are mainly associated with old beech and chestnut. It is sad that precisely these trees are no longer planted. People are only interested in the cultivation of new (exotic) species and varieties. *Quercus* has many types and is therefore often cultivated. Literature mentions a lot of mycorrhizal fungi exclusively connected with oak, but in the Botanic Garden these fungi are only found near the closely related chestnut. Together with the old chestnut trees *Chalciporus rubinus*, *Xerocomus moravicus*, *Gyroporus castaneus*, *Lactarius fulvissimus*, *L. subumbonatus* and *L. chrysorrheus* among others will disappear, the Domain is the sole site of the first two species in Flanders. Since the removal of leaves stopped in many wooded zones, *Boletus satanas*, *Leccinum crocipodium* and *Tricholoma album* have already vanished. Other species such as *Suillus granulatus*, *Lactarius deliciosus* and *Russula odorata* are lost due to the (unnecessary) cutting of the host tree or the layout of new collections.

Valuable spring flora and ectomycorrhizal flora may occur together, but not in exactly the same place: spring flora thrives best on humid soil, the critical mycoflora in dry patches. Until 1995 the management (mowing under the trees from April onwards) was favourable for fungi. Since 1995 mowing under trees has always started much later, often only by the end of June or in July, which is good for (part of) the flora but harmful to the (critical) mycorrhizal fungi.

Good management requires both continuous monitoring and the possibility of annual adaptation.

Woodland zones in the Botanic Garden: no models for nature reserves

The abundance of EM fungi in the managed zones stands in striking contrast with the poverty in the unmanaged areas of the Domain. Since the cultivation of the wooded areas, about 175 years ago, management has been restricted to the removal of fallen trees. With the ageing of the wood this caused the development of active mull under trees with rich humus, so that the trees are not or only marginally dependent on mycorrhiza for the absorption of minerals. Under trees with poor humus mormoder developed, resulting in only a limited variation of niches for mycorrhizal fungi.

The consequences of absence of active management are also visible in forest reserves from which human intervention is completely banned, such as Zofinsky Prales in Czechia (visited in 2003). Since this forest became a reserve in 1838, not a single tree has been removed. They even built a fence to keep deer and wild boar out. Today the wood is particularly rich in saprophytes, especially the species growing on trunks, but the reserve is just as poor in EM fungi as the wooded areas in the Domain of the Botanic Garden! There too we merely find a limited number of common species such as fungi belonging to the genus *Xerocomus*.

In the past decades clear felling has become less popular and is increasingly replaced with selective felling. The wooded areas of the Domain and the Zofinsky Prales forest reserve are examples of how the EM flora in our reserves and managed forests will develop in the future, if we stick to the present management.

References

Arnolds E. & Jansen E. (1992) – New evidence for changes in the macromycete flora of the Netherlands. *Nova Hedwigia* **55**: 325-351.

Arnolds E. & van Ommering G. (1996) – Bedreigde en kwetsbare paddenstoelen in Nederland. Toelichting op de Rode Lijst. *Rapport IKC Natuurbeheer* **24**: 1-120. Wageningen, IKC Natuurbeheer, Min. van Landbouw, Natuurbeheer en Visserij.

Baar J. & Ozinga W. (2007) – Mycorrhizaschimmels: sleutelfactor voor duurzame landbouw en natuur. Zeist, KNNV Uitgeverij.

Burny J. (1999) – Bijdrage tot de historische ecologie van de Limburgse Kempen (1910-1950). Tweehonderd gesprekken samengevat. Maastricht, Natuurhistorisch Genootschap in Limburg.

De Kesel A. (2001) – Paddenstoelen en natuurbeheer in het provinciaal domein d'Ursel te Hingene. *Antwerpse koepel voor natuurstudie, jaarboek* **2000**: 55-69.

Hommel P., de Waal R., Muys B., den Ouden J. & Spek T. (2007) – Terug naar het lindewoud: strooiselkwaliteit als basis voor ecologisch bosbeheer. Zeist, KNNV Uitgeverij.

Kuyper Th., Termorshuizen A. & Boswijk W. (1990) – Ectomycorrhiza en de vitaliteit van het Nederlandse bos. *Nederlands bosbouwtijdschrift* **62**: 334-338.

Ronse A. & Vidts S. (2011) – A short history of the land use and vegetation of the Botanic Garden. *Scripta Bot. Belg.* **47**: 19-26.

Staelens J., De Schrijver A., Verheyen K. & Verhoest N.E.C. (2006) – Spatial variability and temporal stability of throughfall water under a dominant beech (Fagus sylvatica L.) tree in relationship to canopy cover. *Journal of hydrology* **330**: 651-662.

Van de Kerckhove O. (2006) – Boleten in het Domein van Bouchout (Nationale Plantentuin) in Meise. Deel 2: Ecologie van de groeiplaatsen. *Jaarboek VAM* **10 (2005)**: 13-35.

Vera F. (1997) – Metaforen van de wildernis: eik, hazelaar, rund en paard. 's Gravenhage, Min. van Landbouw, Natuurbeheer en Visserij.

Walleyn R. & Verbeken A. (2000) – Een gedocumenteerde Rode Lijst van enkele groepen paddestoelen (Macrofungi) van Vlaanderen. *Mededelingen van het Instituut voor Natuurbehoud* **7**: 1-87. Brussel, INBO.

Scripta Botanica Belgica **47**: 193-194 (2011)

Short note

Gymnosporangium sabinae: such a beautiful disease...

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Scripta Bot. Belg. **47**: I. Hoste (ed.), The spontaneous flora of the National Botanic Garden of Belgium (Domein van Bouchout, Meise)

If, around the first of May, you look at the junipers which are growing near the mess at the National Botanic Garden of Belgium, just at the beginning of the small path leading to the bookshop, you will see that some twigs present swellings on which are growing masses of little orange horns, a bit more than one centimetre long (fig. 1). The origin of that phenomenon is *Gymnosporangium sabinae* (Dicks.) G. Winter. The species belongs to the Uredinales (or 'rust fungi'), a group of fungi which are parasitic on plants. They have a very complicated life cycle, involving up to four different sporiferous stages and, often, an alternation between two different host species.

Gymnosporangium sabinae is known from Belgium for more than 130 years (Vanderweyen & Fraiture 2008). It develops its perfect stage on various species of junipers, in this case, *Juniperus ×pfitzeriana*. Our native juniper, *J. communis*, is not colonized, but it can be infected by two other *Gymnosporangium* species: *G. clavariiforme* and *G. cornutum*. The imperfect stages (anamorphs), which produce spores without fertilization, grow on the leaves of some species of the genus *Pyrus*, e.g. the common pear tree (*Pyrus communis*). On these trees they produce what is called the 'pear trellis' or, in French, 'rouille grillagée' (Vanderweyen 2002, Vanderweyen & Geerinck 2006).

In the spring of 2008, one of us (AV), a phytopathologist, examined all the juniper trees growing in the coniferetum of the Botanic Garden in search of *Gymnosporangium*. He came

Figure 1. Gymnosporangium sabinae *(stage III) on* Juniperus ×pfitzeriana, *in Meise. The cornicula are already a bit faded, partly due to drought. (Photo A. Fraiture)*

back empty-handed and complained: "Your trees are desperately healthy. It's a scandal. Such a beautiful disease!"

Bibliography

Vanderweyen A. (2002) — Gymnosporangium sabinae, la rouille grillagée du Poirier. *Rev. Cercle Mycol. Bruxelles* **2**: 65-80.

Vanderweyen A. & Geerinck D. (2006) — La rouille grillagée (Gymnosporangium sabinae) sur Pyrus calleryana. *Rev. Cercle Mycol. Bruxelles* **6**: 41-48.

Vanderweyen A. & Fraiture A. (2008) — Catalogue des Urédinales de Belgique, 2e partie: Pucciniaceae (sauf Puccinia). *Lejeunia* NS **185**.

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Short note

Observation of *Lindtneria leucobryophila* in the greenhouses of the Botanic Garden

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Scripta Bot. Belg. **47**: I. Hoste (ed.), The spontaneous flora of the National Botanic Garden of Belgium (Domein van Bouchout, Meise)

Résumé. – *Lindtneria leucobryophila* a été récolté sur le sol d'une serre tropicale du Jardin botanique national de Belgique (BR). Le spécimen est brièvement décrit.

Samenvatting. – *Lindtneria leucobryophila* werd op de grond in een tropische kweekkas van de Nationale Plantentuin van België (BR) waargenomen. Het materiaal wordt kort beschreven.

Introduction

At the very beginning of the year 2010, my colleague Viviane Leyman sent me a sample collected from the tropical greenhouses of the National Botanic Garden of Belgium (BR, greenhouse 600[3] of the Plant Palace). It consisted in patches of a mycelium, coloured in a rather vivid orange yellow, which were growing on the soil surface and looked like a hyphomycete. The examination with the microscope showed that the fungus belonged to the corticioid Basidiomycetes. It was finally identified as *Lindtneria leucobryophila*.

Description of the collected specimen

Specimens examined. Belgium, Meise, National Botanic Garden of Belgium, in greenhouse 600[3] of the Plant Palace, 04.01.2010, specimen *A. Fraiture 3153*, ibid., 04.02.2010, specimens *A. Fraiture 3155* (same colour as *3153*) and *3156* (paler specimen). The three specimens are preserved at BR.

• *Carpophore* spread as a thin crust, more or less tuberculate (probably due to the irregularities of the substrate), orange yellow to egg yellow (Methuen* 4A8, 5A7, specimens 3153 and 3155) or much paler, ochraceous pink (Methuen 5A3, specimen 3156). Margin whitish. *Context* very tender, soft and a bit succulent, coloured in a deeper and darker orange than the surface (binocular). No special smell. Taste not tested.

• *Spores* hyaline, cyanophilous, not amyloid, of (6,5-)7,0-8,0(-10,0) × (4,5-)5,0-5,5(-7,0) µm (without ornamentation), broadly ellipsoid to ellipsoid-fusiform (mean Q = 1,31 ; "Q" is the ratio length/width), ornamented with spines 0,5-1,0(-1,5) µm long, isolated or sometimes fused in short crests; some spores are also bearing a raised 'collerette' situated on the margin of the hilar plage and giving the impression (under the light microscope) that those spores wear a 'bib' as we put on young children. The scanning electronic microscope (SEM) allows us to see that this collerette (which is called a 'crown' in *Lindtneria*) reaches the apiculus when it is very well developed, but this is more often not the case (Fig. 1). *Basidia* terminal, 4-sporic, clamped, of about 30-45(-55) × 8-10(-10,5) µm, hyaline, with a thin and smooth wall, containing numerous guttules 1-2 µm diam., which are strongly cyanophilous (less pronounced in mature basidia) but not amyloid. *Trama* monomitic, hyphae 3-7 µm

* The *Methuen handbook of colour* (Methuen Publishing Ltd, 3rd revised edition, 1978) is a colour code which is often used by mycologists.

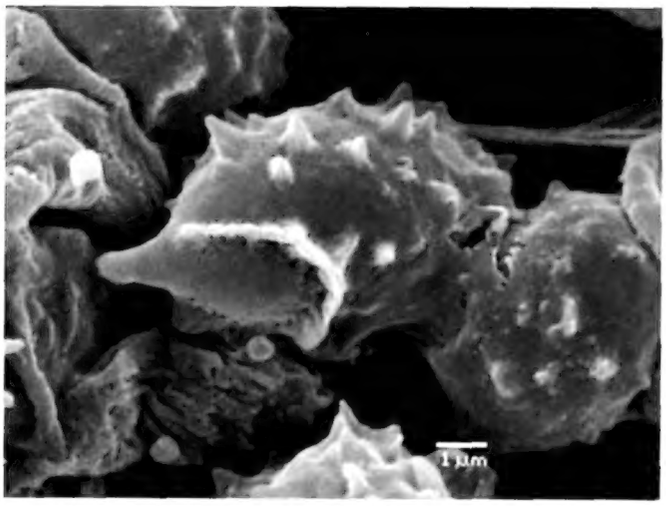

Figure 1. Lindtneria leucobryophila, *spore seen with the electronic microscope. (SEM ; photo F. Van Caekenberghe, BR) The conical spines and the 'collerette' surrounding the plage are clearly visible.*

diam., hyaline, with a thin and smooth wall, not cyanophilous, not amyloid. Clamps frequent.

• *Ecology*: on naked soil, in a tropical greenhouse.

Identification of the collection

The monomitic trama, the presence of cyanophilous globules in the basidia as well as the cyanophilous spores, ornamented with spines and provided with a crown, lead to the conclusion that the specimens belong to the genus *Lindtneria* (Fraiture, in prep.). It is a genus of corticioid Basidiomycetes that shows affinities with the Russulales and the Agaricales, but its exact taxonomic position is not determined yet.

The spores, broadly ellipsoid to ellipsoid (mean Q =1,30), more than 6 µm long, not surrounded by a wing but provided with a crown around the hilar plage, as well as the basidia relatively elongated and the smooth to tuberculate hymenophore allow us to identify the collection as *Lindtneria leucobryophila* (Henn.) Jülich [syn.: *Thelephora leucobryophila* Henn., *Trechispora leucobryophila* (Henn.) Liberta]. As Trichies (1999) points out, *L. flava* Parmasto and *L. panphyliensis* Bernicchia & M.J. Larsen are very close to *L. leucobryophila* and perhaps even conspecific, the characters used to separate these three species being variable and having low taxonomic value.

Ecology and distribution

Lindtneria leucobryophila grows on various organic substrates such as mosses (e.g. *Leucobryum*, hence the name), rotten herbaceous plants, leaves, bark and rotten wood of broad-leaved and coniferous trees. A collection, very similar to ours, has been made by Gsell (1989, sub *L. flava*), in the greenhouses of the Botanic Garden of Zurich. It seems that the species is mainly observable from December through March (or early April) (Robinson 1995, Gsell 1989).

Ryvarden & Gilbertson (1993) say that *L. leucobryophila* is very rare. Up to now, it seems that the species has only been observed in Europe (Norway, Denmark, Germany, GD of Luxembourg, Belgium, France, the former Yugoslavia, Switzerland, Italy, Spain, Great Britain). However, *L. flava*, which is perhaps no more than a synonym, has been collected also in the USA and in Africa.

Two mentions from Belgium already existed in the 'Funbel' database (KVMV, manager: E. Vandeven). The first one is an observation made at Oostduinkerke, Hannecartbos (IFBL C0.48.42), on 08.12.2004, by W. Termonia (no specimen preserved), the second one is a collection made by the 'Paddenstoelenwerkgroep Meetjesland' at Landegem, Kanaal (IFBL D2.18.33) on 16.02.2005, on a dead branch of *Salix*, and identified by J. Schoutteten (herb. *R. Walleyn 38*, GENT). I did not revise this specimen. It seems that no other Belgian records of *L. leucobryophila* exist.

Acknowledgements. – Frank Van Caekenberghe (BR) took the picture with the electronic microscope (SEM), Sven Bellanger (BR) prepared it for publication and Emile Vandeven sent us an extract of the database Funbel (KVMV) concerning the two collections made in Flanders. I thank them very much for their efficient help.

Bibliography

Fraiture A. (in prep.) – Synopsis du genre Lindtneria. [To be published in *Scripta botanica belgica*]

Gsell H. (1989) – *Lindtneria flava*, une récolte intéressante dans le Jardin botanique de Zurich. *Schweiz. Z. Pilzk.* **67 (9/10)**: 178-181.

Robinson K. (1995) – Some resupinate fungi from Hertfordshire. *Mycologist* **9 (3)**: 135-137.

Ryvarden L. & Gilbertson R.L. (1993) – European polypores, 1. Abortiporus-Lindtneria. *Synopsis fungorum* **6**. Oslo, Fungiflora.

Trichies G. (1999) – À propos des Lindtneria européens à spores fusiformes-ellipsoïdales. *Bull. trim. Soc. mycol. France* **115(1)**: 65-78.

Scripta Botanica Belgica **47**: 198 (2011)

Short note

Duchesnea indica, *Frommeëlla mexicana*, and associated organisms: a little ecosystem on a potentially invasive plant

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Scripta Bot. Belg. **47**: I. Hoste (ed.), The spontaneous flora of the National Botanic Garden of Belgium (Domein van Bouchout, Meise)

The rust fungus (Uredinales) *Frommeëlla mexicana* (Mains) J.W. McCain & J.F. Hennen has been recently and newly discovered in Belgium in the Domain of Bouchout (Fraiture & Vanderweyen 2007). It was abundantly developed on the sub-invasive plant *Duchesnea indica* (Andrews) Focke (Rosaceae). The host-parasite relationship is here exclusive because the plant is the only host known for the parasite, which is itself the only rust fungus growing on *Duchesnea* and does not alternate with another host.

When studying different collections of the fungus, Fraiture & Vanderweyen (2007) observed three different organisms growing on it (hyperparasites). The first organism forms tiny black points in the uredia. It is *Eudarluca caricis* (Fr.: Fr.) O.E. Erikss. (Pleosporales, Ascomycetes) which is a parasite of Uredinales. The second one, *Lecanicillium muscarium* (Petch) Zare & W. Gams, is a whitish mould (anamorphic Hypocreales, Ascomycetes) also growing on the uredia. The third one is an insect (*Mycodiplosis* sp., Cecidomyiidae, Diptera), the larvae of which eat *Frommeëlla*'s uredospores.

It is interesting to note that those five species are forming together a small ecosystem in which they are situated at different trophic levels of the ecological pyramid. The base of the pyramid is constituted by the plant which, due to the presence of chlorophyll, is autotrophic and produces organic matter starting from inorganic matter. The rust fungus *Frommeëlla* is the primary consumer, which feeds on the plant. The three other organisms (*Eudarluca*, *Lecanicillium* and *Mycodiplosis*) are secondary consumers, feeding on the *Frommeëlla*.

Another point which deserves to be stressed is that *Duchesnea indica* is not native to Europe (Verloove 2006) and that its presence as a sub-spontaneous (or potentially invasive) species allows the development of the fungus, also non-native to Europe, which constitutes itself a source of food for the three other specialised species.

Bibliography

Fraiture A. & Vanderweyen A. (2007). — Frommeëlla mexicana, nouvelle rouille pour la flore belge, et trois hyperparasites vivant à ses dépens. *Rev. Cercle Mycol. Bruxelles* **7**: 8–20. [pdf version available at http://www.cercle-myco-bruxelles.be/Publications.html]

Verloove F. (2006). — *Duchesnea indica*. *In*: Van Landuyt *et al.*, Atlas van de flora van Vlaanderen en het Brussels Gewest: 152. Brussel & Meise: INBO, Nationale Plantentuin van België & Fl. Wer.

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Aquatic diatoms (Bacillariophyta) from a small pool at the herbarium building

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Résumé. Les diatomées dulçaquicoles (Bacillariophyta) d'un petit étang dans le Jardin botanique national de Belgique. La flore diatomique d'un petit étang situé au milieu du bâtiment d'herbier du Jardin botanique national de Belgique a été analysée. Dans 6 échantillons, une flore bien développée, composée de 63 taxons appartenant à 25 genres a été trouvée. Deux espèces, nouvelles pour la science, co-dominaient la flore: *Eunotia belgica* et *Encyonopsis horticola*. On a observé une différence nette entre les échantillons pris dans la partie ombragée et les échantillons provenant de la partie ensoleillée. La composition spécifique de la zone ombragée était dominée par des espèces eutrophes comme *Amphora pediculus* tandis que la partie ensoleillée était caractérisée par des espèces oligo- à mésotrophes comme *Cymbella cymbiformis* et *Encyonopsis subminuta*.

Samenvatting. Aquatische diatomeeën (Bacillariophyta) in een geïsoleerde vijver van de Nationale Plantentuin van België. De diatomeeënsamenstelling van een kleine vijver, gesitueerd in het midden van het herbariumgebouw van de Nationale Plantentuin van België werd geanalyseerd. In zes monsters werd een zeer diverse diatomeeënflora aangetroffen bestaande uit 63 taxa, behorend tot 25 genera. Twee soorten, die als nieuw voor de wetenschap werden beschreven, co-domineerden de flora: *Eunotia belgica* en *Encyonopsis horticola*. Er was een duidelijk verschil tussen de monsters die genomen werden aan de zonnige zijde van de vijver in vergelijking met monsters, verzameld aan de schaduwkant. De diatomeeënsamenstelling aan de schaduwzijde werd gekarakteriseerd door eutrafente soorten zoals *Amphora pediculus*, terwijl de zonnige zijde werd gedomineerd door oligo- tot mesotrafente soorten zoals *Cymbella cymbiformis* en *Encyonopsis subminuta*.

Introduction

Diatoms (Classis Bacillariophyta) are one of the most abundant and species-rich algal groups in both standing and flowing waterbodies (Round *et al.* 1990). These unicellular algae are characterized in having an ornamented silica outer shell (SiO_2) on which the identification is largely based. They form an important component of the food chain because of their large contribution on both the oxygencycle in the atmosphere and the primary production in freshwater, terrestrial and marine ecosystems. Almost every species has its own typical ecological preferences, making them excellent bio-indicators for water quality monitoring purposes. Worldwide, almost 30,000 species are known (Mann & Droop 1996), mostly present in marine circumstances. New species are continuously being described (e.g. Van de Vijver & Matalomi 2008).

Following a floristic inventory of the National Botanic Garden, the diatom flora in several samples from a small enclosed pool, located in the herbarium building, has been analysed. The present note discusses the results of this diatom survey.

Study area

The herbarium building of the National Botanic Garden was constructed between 1959 and 1962 in the *Domein van Bouchout*, situated at the Nieuwelaan in Meise (Prov. Vlaams-Brabant). In the middle of the building, a small courtyard was laid out with a small pond (= 'enclosed pool'). The first 20 years of its existence, the courtyard was not isolated since the galleries bordering the yard were open. It is only after 1980 that the galleries were closed, isolating that way the pool from the rest of the Botanic Garden. Only by air the pool was in contact with the outer world since a roof was never constructed.

Several years before the isolation, in 1978, aquatic plants were installed in the pool, originating from a pool at the Agricultural Institute in Vilvoorde and some waterbodies in Flanders (Leo Vanhecke, pers. communication). At the start of the 1990s, the decision was taken to stop all management in the pool and to let the surrounding vegetation develop spontaneously. Until now, the natural succession has continued without any human influence. An overview of the vegetation of the inner courtyard is reported by Hoste & Geerinck (2011).

The vegetation in the enclosed pool is dominated by *Ceratophyllum demersum*, *Myriophyllum spicatum* and several *Nymphaea* species. In the past, frog and carp species have been introduced in the pool leading to large established populations. Ducks visit the pool regularly.

Methods

A total of six samples have been investigated. In June 2009, three samples have been collected under the shade of the luxuriant *Salix* vegetation (samples 1-3) and three other samples were taken on the sunny side of the enclosed pool (library-side, samples 4-6). Each subset consists of one sample taken from the squeezing of floating *Ceratophyllum demersum* (samples 1 and 4), one sample scraped off from the pool edge at a depth of about 15 cm (samples 2 and 5) and a third sample taken from sediment collected at a depth of 50 cm (samples 3 and 6), in an attempt to maximize the microhabitat-variation in the entire pool. Due to logistic constraints, only a small number of physico-chemical parameters have been measured in the pool: the pH is 7.5 and the specific conductance value is 330 µs/cm.

The six samples have been prepared following the method described in Van der Werff (1955). Small parts of the samples were cleaned by adding 37 % H_2O_2 and heating to 80 °C for about one hour. The reaction was completed by addition of $KMnO_4$. Following digestion and centrifugation (three times 10 minutes at 3700× g), the resulting clean material was diluted with distilled water to avoid excessive concentrations of diatom valves on the slides. Cleaned diatom material was mounted in Naphrax®. The slides were analyzed at 1000× magnification using an Olympus BX51 microscope, equipped with Differential Interference Contrast (Nomarski) optics and the Colorview I Soft Imaging System. Samples and slides are stored at the National Botanic Garden (Belgium). The identification is based on Krammer & Lange-Bertalot (1986-1991), Krammer (1997, 2002) and Lange-Bertalot (2001). In each sample, 400 diatom valves were counted on random transects followed by the scanning of an entire slide to find rare species absent in the counts.

Since diatoms often have strict ecological preferences, it is possible to use these preferences to reconstruct the chemical properties of their aquatic environment. One of these reconstructions is based on the ecological indicator values by Van Dam *et al.* (1994) that quantify several ecological parameters for diatoms (pH, salinity, trophic situation, saprobity). For the present study, a reconstruction of the pH and trophic situation of the enclosed pool was made, based on the entire diatom composition and for each of the pool sides separately.

Species composition

A total of 63 diatom taxa, belonging to 25 genera have been found. Table 1 shows the list of all observed taxa. The most species rich genera include *Nitzschia* (11 species), *Navicula*

(8), *Staurosira* (7) and *Cocconeis* (4), whereas based on the number of counted valves, *Amphora* (43,6 % of all counted valves), *Navicula* (25,8 %), *Encyonopsis* (25 %) and *Nitzschia* (24,5 %) were the principal genera.

Table 1. List of all observed species in the enclosed pool of the herbarium building.

Achnanthidium exiguum (Grunow) Czarnecki
Achnanthidium minutissimum sl (Kützing) Czarnecki
Achnanthidium straubianum (Lange-Bertalot) Lange-Bertalot
Adlafia bryophila (Petersen) Lange-Bertalot
Amphora pediculus (Kützing) Grunow
Caloneis bacillum (Grunow) Cleve sensu auct. nonnull.
Caloneis fontinalis (Grunow) Lange-Bertalot & Reichardt
Cocconeis neodiminuta Krammer
Cocconeis placentula var. *euglypta* Ehrenberg
Cocconeis placentula var. *lineata* (Ehrenberg) Van Heurck
Cocconeis placentula var. *pseudolineata* Geitler
Craticula submolesta (Hustedt) Lange-Bertalot
Cymbella cymbiformis Agardh
Cymbella proxima Reimer
Diadesmis contenta (Grunow) D.G. Mann
Encyonopsis sp.
Encyonopsis subminuta Krammer & Reichardt
Eolimna minima (Grunow) Lange-Bertalot
Epithemia adnata (Kützing) Brébisson
Eunotia ambivalens Lange-Bertalot
Eunotia minor (Kützing) Grunow
Eunotia sp.
Fragilaria bidens Heiberg
Fragilaria nanana Lange-Bertalot
Fragilaria vaucheriae (Kützing) Petersen
Gomphonema parvulum Kützing
Gomphonema productum (Grunow) Lange-Bertalot & Reichardt
Gomphonema truncatum Ehrenberg
Hippodonta pseudopinnulana Lange-Bertalot
Navicula antonii Lange-Bertalot
Navicula cari Ehrenberg
Navicula cryptotenella Lange-Bertalot
Navicula cryptocephala Kützing
Navicula gregaria Donkin
Navicula radiosa Kützing
Navicula veneta Kützing
Navicula wildii Lange-Bertalot
Nitzschia acidoclinata Lange-Bertalot
Nitzschia archibaldii Lange-Bertalot
Nitzschia capitellata Hustedt
Nitzschia dissipata (Kützing) Grunow
Nitzschia draveillensis Coste & Ricard
Nitzschia fonticola Grunow
Nitzschia gracilis Hantzsch
Nitzschia liebetruthii Rabenhorst
Nitzschia palea (Kützing) W. Smith
Nitzschia paleacea Grunow
Nitzschia sinuata var. *delognei* (Grunow) Lange-Bertalot
Pinnularia microstauron (Ehrenbegr) Cleve
Planothidium lanceolatum (Brébisson) Lange-Bertalot
Platessa conspicua (A. Mayer) Lange-Bertalot
Sellaphora seminulum (Grunow) D.G. Mann
Stauroneis kriegeri Patrick
Stauroneis thermicola (Petersen) Lund
Staurosira venter var. *binodis* (Ehrenberg) Cleve & Moeller
Staurosira brevistriata Grunow
Staurosira construens Ehrenberg
Staurosira elliptica (Schumann) Cleve & Moeller
Staurosira leptostauron (Ehrenberg) Hustedt
Staurosira pinnata Ehrenberg
Staurosira venter (Ehrenberg) Cleve & Moeller
Stephanodiscus hantzschii Grunow
Ulnaria acus (Kützing) Aboal

The most dominant species is *Amphora pediculus* (21,8 %), followed by *Encyonopsis subminuta* (9,4 %), *Navicula cryptotenella* (7,9 %), *Eunotia belgica* (7,8 %), *Achnanthidium minutissimum* s.l. (6,6 %) and *Staurosira venter* (5,6 %). Figure 1 shows light microscopical views of the principal diatom taxa observed in the samples.

The absence of planktonic taxa is remarkable. Only one single valve of *Stephanodiscus hantzschii* has been observed whereas other typical species are entirely absent. Normally, planktonic diatoms such as *Asterionella formosa* prevail in these circumstances. The study of the plankton was, however, not included in this study but since diatom valves remain in the sediment for a long time, the absence of these planktonic taxa in the studied sediment samples indicates the poor development of the diatom plankton.

An average of 33 taxa was observed in the samples. The samples taken in the shaded side contained more taxa than the sunny side samples (45 vs. 35). The diatom composition shows some remarkable differences between the two sides (Table 2). On the shaded side, the flora is dominated by *Amphora pediculus*, *Eunotia belgica*, *Staurosira venter*, *Platessa conspicua* and *Cocconeis placentula* ssp., whereas the sunny side is characterized by *Nitzschia* taxa (*N. gracilis*, *N. archibaldii*, *N. paleacea*),

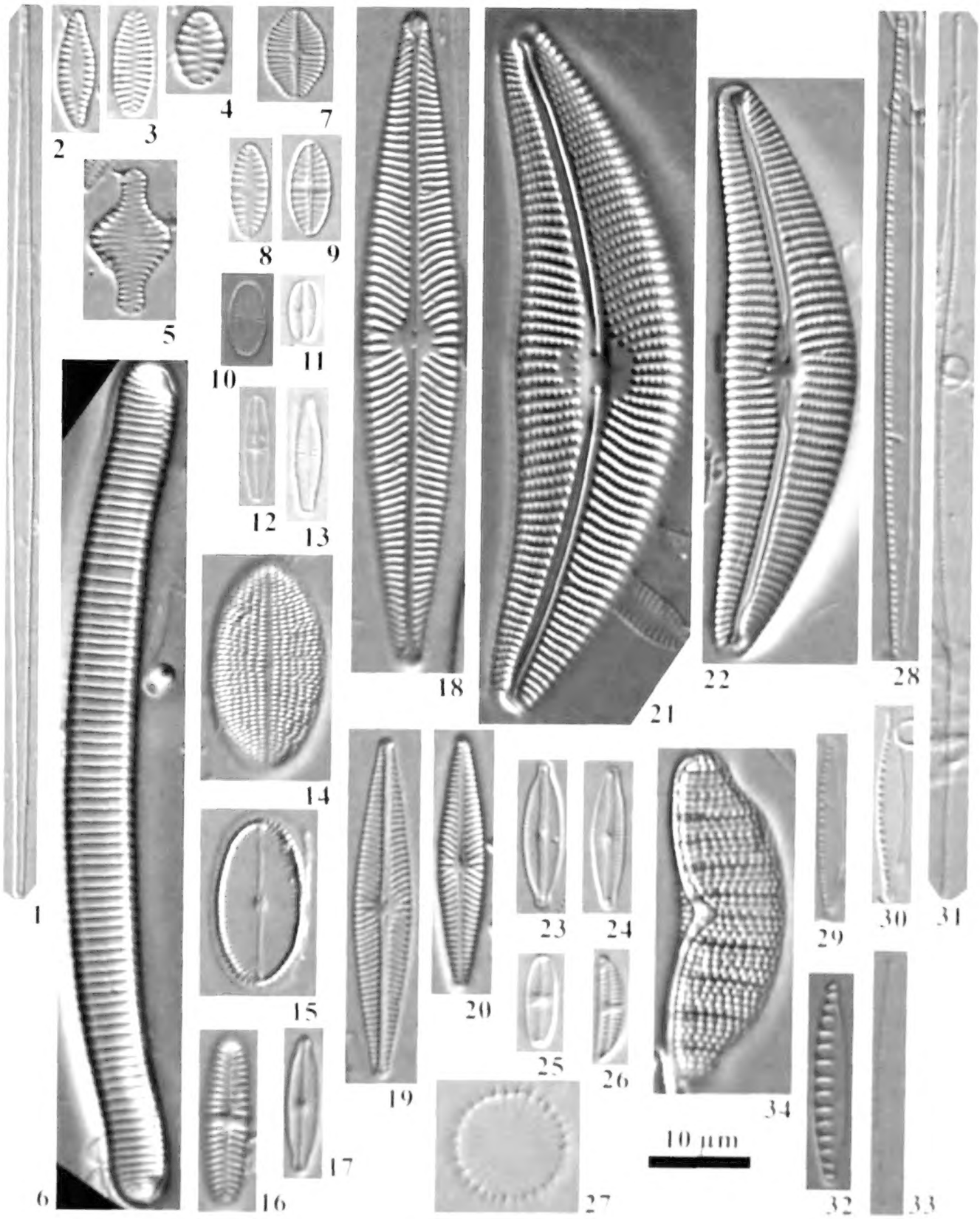

Figure 1. Light microscopical observations of diatoms observed in the sediment of Lake Tjeukemeer. 1 Tetracyclus nanana. *2* Staurosira brevistriata. *3* Staurosirella pinnata. *4* Staurosira venter. *5* Staurosirella pinnata. *6* Eunotia bilunaris. *7* Achnanthidium exiguum. *8-9* Platessa conspicua. *10-11* Achnanthidium straubianum. *12-13* Achnanthidium minutissimum. *14-15* Cocconeis placentula var. lineata. *16* Hippodonta pseudolineolata. *17* Nitzschia brysophila. *18* Navicula radiosa. *19* Navicula schadei. *20* Navicula cryptotenella. *21* Cymbella proxima. *22* Cymbella cymbiformis. *23* Encyonopsis subminuta. *24* Encyonopsis horstiicola. *25* Eolimna minima. *26* Amphora pediculus. *27* Stephanodiscus hantzschii. *28* Nitzschia gracilis. *29* Nitzschia palacea. *30* Nitzschia frustulum. *31* Nitzschia dissipata subsp. dissipata. *32* Nitzschia sinuata var. delognei. *33* Nitzschia archibaldii. *34* Epithemia adnata. *Scale bar represents 10 µm.*

Navicula taxa (*N. cryptotenella*, *N. radiosa*) and *Encyonopsis* taxa (*E. subminuta*, *E. horticola*). This clear difference is remarkable since *Nitzschia* and *Navicula* usually contain motile, epipelic species whereas taxa such as *Amphora pediculus*, *Staurosira venter* and *Cocconeis placentula* are usually attached species. Within each side, no distinct differences between the samples were found.

Interesting species

Although most of the diatom composition contains only widely distributed species, several interesting taxa were observed. Moreover, two species were found that have been described as new to science (Van de Vijver *et al.* 2009).

• *Eunotia belgica* (Figure 1/6)
This rather large *Eunotia* species is present in all three samples from the shaded side and shows some similarity with *Eunotia glacialifalsa* Lange-Bertalot, but differs in several features such as structure of the striae, valve dimensions and shape of the valve, excluding all conspecificity. The species, recently also found in Italy (Lange-Bertalot, pers. comm.), has been described as new to science (Van de Vijver *et al.* 2009).

• *Encyonopsis horticola* (Figure 1/24)
The genus *Encyonopsis* has been revised almost 15 years ago (Krammer 1997). One of the main conclusions was the splitting of the catch-all species *Cymbella microcephala* Grunow [now *E. microcephala* (Grunow) Krammer], into several well-defined new taxa. A result of this revision was that several European populations could no longer be identified as *C. microcephala* and needed to be separated. Most species are known from oligotrophic, rather cold circumstances as often found in northern European regions. In the samples from the sunny side, a large population of a member of this complex was found showing significant morphological and ecological differences from all taxa, described so far from this complex. Detailed morphological research already showed that the species was unique

Table 2. Overview of all dominant species in the different samples from the enclosed pool of the herbarium building with their relative abundance. W: >10 %; O: 5-10 %; +: 2-5 %; °: <2 %; -: present but outside counts.

	1	2	3	4	5	6
Amphora pediculus	X	X	X	+	O	°
Achnanthes conspicua	O	°	°	-	°	°
Navicula cryptotenella	O	O	+	O	+	X
Eunotia sp.	°	X	°	°	-	°
Cocconeis placentula var. *euglypta*	°	O	°	°	-	°
Cocconeis placentula var. *lineata*	°	O	°	°	-	-
Staurosira construens	°	°	X	°	O	°
Staurosira venter	-	-	X	°	O	°
Achnanthidium minutissimum sl.	O	+	+	X	°	+
Encyonopsis sp.	°	°	°	X	+	°
Encyonopsis subminuta	+	+	+	X	O	X
Nitzschia paleacea	°	°	°	O	°	O
Adlafia bryophila	-	°	°	O	+	°
Achnanthidium straubianum	°	°	°	O	X	°
Nitzschia archibaldii	°	°	°	+	X	°
Nitzschia gracilis	°	°	°	+	X	O
Navicula radiosa	°	+	°	+	°	X
Cymbella cymbiformis	°	°	°	+	+	+
Nitzschia fonticola	°	°	°	+	+	°
Eolimna minima	+	°	°	°	+	°

justifying its description as a new species (Van de Vijver *et al.* 2009). Recently, the species was observed in several Portuguese rivers (Ector, pers. comm.).

• *Cymbella cymbiformis* (Figure 1/22)
This species has its main distribution in the arctic, subarctic and temperate regions with a preference for oligotrophic lakes and rivers (Krammer 2002). In the enclosed pool, the species is mainly found in the samples from the sunny side while the species is absent in the shaded samples.

• *Hippodonta pseudopinnularia* (Figure 1/16)
According to Lange-Bertalot (2001), this species is only known from its type locality in Danmark. The presence of this species (although only one single valve was found) in the enclosed pool is therefor quite remarkable.

Diatoms and environmental reconstruction

Figure 2 and figure 3 show the distribution of the species in the different pH and trophic classes. These results confirm that the enclosed pool has a species composition typical for a circumneutral to slightly alkaline pH (~7), consistent with the pH measurement, and for meso- to eutrophic conditions. No difference in pH was observed between both sides of the enclosed pool.

On the other hand, there is a large difference in the trophic condition of both sides. The shaded samples indicate the presence of meso- to eutrophic conditions whereas the sunny side is rather mesotrophic. This large difference is the result of the dominance of the eutraphentic taxon *Amphora pediculus*, dominating the shaded samples, contrary to the dominance of the oligotraphentic to mesotraphentic *Cymbella* and *Encyonopsis* species, prevailing at the sunny side. It is highly likely that this difference in species composition is caused by the decomposition of decaying leaves that is obviously larger at the shaded side compared to the sunny side, where fewer trees are present.

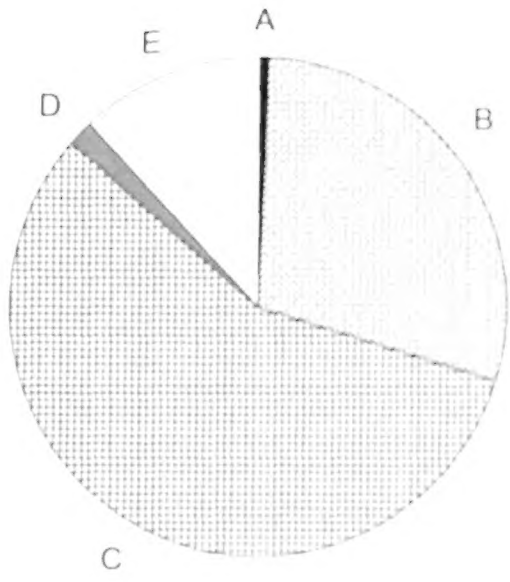

Figure 2. pH preferences of the observed species in the enclosed pool, based on Van Dam et al. (1994). A = acidophilous (pH < 7), B = circumneutral (pH ~ 7), C = alkaliphilous (pH > 7), D = alkalibiontic (pH > > 7), E = no data available.

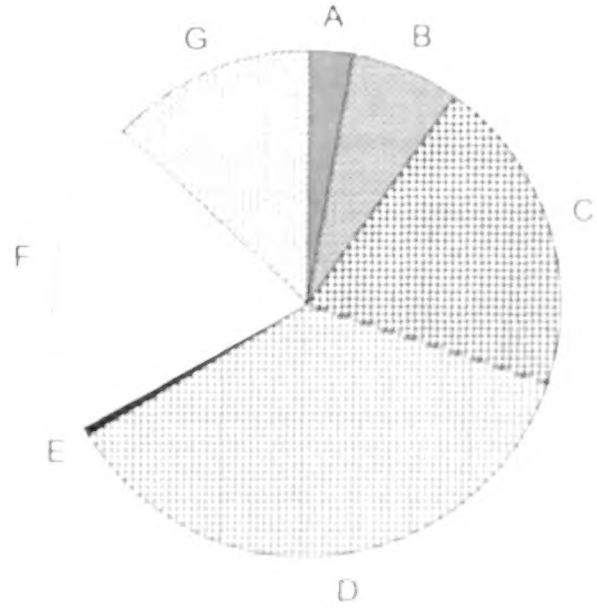

Figure 3. Trophic preferences of the observed species in the enclosed pool, based on Van Dam et al. (1994). A = oligotraphentic, B = oligo-mesotraphentic, C = mesotraphentic, D = meso-eutraphentic, E = eutraphentic, F = indifferent, G = no data available.

Conclusion

This small study clearly shows that the enclosed pool in the herbarium building presents an interesting habitat for diatoms. Further research on this diatom composition will therefore be necessary to fully understand the diatom flora of this small pool.

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References

Hoste I. & Geerinck D. (2011) – The vegetation of the enclosed courtyard at the herbarium building. *Scripta Bot. Belg.* **47**: 145-153.

Krammer K. & Lange-Bertalot H. (1986-1991) – Bacillariophyceae. Teil 2/1-2/4. *In* Ettl *et al.* (eds.), Süsswasserflora von Mitteleuropa. Stuttgart-New York, Gustav Fisher Verlag.

Krammer K. (1997) – Die cymbelloiden Diatomeen. Eine Monographie der weltweit bekannten Taxa. Teil 2. Encyonema part. Encyonopsis and Cymbellopsis. *Bibl. Diatom.* **37**: 1-469.

Krammer K. (2002) – Cymbella. *Diatoms of Europe* **3**: 1-584.

Lange-Bertalot H. (2001) – Navicula sensu stricto, 10 Genera separated from Navicula sensu lato, Frustulia. *Diatoms of Europe* **2**: 1-526.

Mann D.G. & Droop S.J.M. (1996) – Biodiversity, Biogeography and conservation of diatoms. *Hydrobiol.* **36**: 19-32.

Round F.E., Crawford R.M. & Mann D.G. (1990) – The diatoms. Biology & morphology of the genera. Cambridge, Cambridge University Press.

Van Dam H., Sinkeldam J. & Mertens A. (1994) – A coded checklist and ecological indicator values of freshwater diatoms from The Netherlands. *Neth. J. Aquat. Sci.* **28**: 117-133.

Van de Vijver B. & Mataloni G. (2008) – New and interesting species in the genus Luticola D.G. Mann (Bacillariophyta) from Deception Island (South Shetland Islands). *Phycologia* **47**: 451-467.

Van de Vijver B., Lange-Bertalot H. & Compère P. (2009) – Two new freshwater diatom taxa (Bacillariophyceae) from a small pool in the National Botanic Garden of Belgium. *Belgian Journal of Botany* **142(2)**: 194-203.

Van der Werff A. (1955) – A new method for cleaning and concentrating diatoms and other organisms. *Verh. Int. Verein. Theor. Angew. Limnol.* **12**: 276-277.

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Biodiversity and land management within the Domain of the Botanic Garden

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Scripta Bot. Belg. **47**: I. Hoste (ed.), The spontaneous flora of the National Botanic Garden of Belgium (Domein van Bouchout, Meise)

Résumé. – La biodiversité et la gestion des terrains dans le Domaine du Jardin botanique national de Belgique. Les différents textes dans *Scripta Botanica Belgica* n° 47 mettent en évidence la très grande biodiversité présente dans le Domaine du Jardin botanique. Dans cette contribution, la distribution de la diversité est analysée pour les groupes d'organismes pour lesquels un inventaire exhaustif a été fait, notamment les plantes vasculaires, les myxomycètes, les lichens et les espèces rares de champignons ectomycorhiziques. Les résultats démontrent que les zones de haute diversité diffèrent selon les groupes d'organismes. L'utilisation des terrains et leur gestion sont particulièrement importantes pour expliquer cette distribution. Sur base des résultats obtenus, des recommandations sont formulées pour une meilleure gestion biologique en fonction des groupes d'organismes.

Samenvatting. – De biodiversiteit en het beheer in het Domein van de Nationale Plantentuin van België. Uit de teksten in *Scripta Botanica Belgica* nr. 47 blijkt dat het Domein van de Nationale Plantentuin een zeer hoge biodiversiteit bevat. In deze bijdrage wordt de ruimtelijke verspreiding van de diversiteit geanalyseerd voor de verschillende soortengroepen waarvoor een gebiedsdekkende inventaris beschikbaar is, met name vaatplanten, myxomyceten (slijmzwammen), lichenen en zeldzame ectomycorrhizapaddenstoelen. Hieruit blijkt dat de biodiversiteit verspreid is over het hele Domein, met topsectoren die wisselen naar gelang van de beschouwde soortengroep. Zowel het landgebruik (bos, grasland of sterk verstoord gebied) als het type van graslandbeheer (maaifrequentie en -hoogte) zijn hierbij van belang. Aan de hand van die bevindingen kunnen, telkens in functie van de bestudeerde soortengroepen, richtlijnen geformuleerd worden voor het beheer.

Introduction

The contributions in this volume clearly show that the Domain of the National Botanic Garden of Belgium contains large numbers of species for all groups of organisms that have been studied. It can even be called a hotspot for lichens (Van den Broeck & Ertz 2011), ectomycorrhizal fungi (Van de Kerckhove 2011), and Laboulbeniales (De Kesel & Gerstmans 2011). Moreover, it holds valuable vegetation and several rare native species of plants and fungi.

A first question that arises is whether these organisms are concentrated in the same or different areas of the Domain. Have certain areas of the Domain a higher biodiversity and hence a higher conservation value than other areas? A second set of questions concerns the relationship between the occurrence of species worthy of conservation, and management practices in the areas in which these species occur. How can the conservation of these species be secured and what can be done in terms of management, in order to secure or increase the native biodiversity within the Domain? A third issue is the recommendation of conservation strategies for particular groups of organisms.

The distribution of the biodiversity within the Domain

The distribution of the biodiversity within the Domain has been analyzed by comparing the number of species per sector for each group of organisms that have been recorded, as well as the number of species that are rare in Flanders. This includes the vascular plants (Ronse 2011), the lichens (Van den Broeck & Ertz 2011) and the ectomycorrhizal fungi (Van de Kerckhove 2011); of the latter group only rare species have been recorded intensively. For the vascular plants, among the rare species only native plants have been considered. There are also many rare plants that have escaped cultivation in the Garden, but these have little conservation value. We have also used data on the lignicolous and folicolous myxomycetes that were mostly recorded between 2000 and 2010 by S. De Pauw and M. de Haan. It appears that for each group of organisms the highest diversity is situated in different parts of the Domain, although there is some overlap between the groups (Ronse *et al.*, in prep.).

In order to have a general idea of the sectors with the highest overall diversity for the four groups that have been studied, we have pooled the results of all taxonomic groups. This was done by assigning a score of 1, 2 or 3 to each sector, according to its diversity (low, medium or high) for each group of organisms. These scores were then added per sector and averaged, yielding a global diversity score of 1 to 3 per sector. The data for the lichens were not included, since the survey of this group has not been completed for all sectors. The resulting distribution of the overall diversity is given in figure 1. It shows that the sectors with a high diversity lie in the eastern part of the grounds of the Botanic Garden, around the castle and the castle lane, as well as in the western part, and they are linked by a corridor of sectors that mostly lie next to the streamlet Amelsvonnebeek. Furthermore, the sectors 29, 53, 54 and 59 also contain a high diversity.

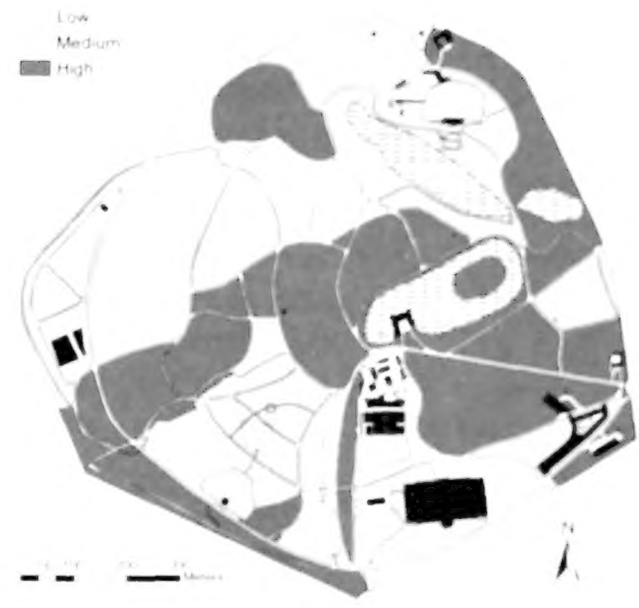


Figure 1. Distribution of biodiversity in the Botanic Garden, based on data collected per sector.

In some of these sectors rare species have been found of other taxonomic groups that have not yet been thoroughly investigated in the Botanic Garden. A fine example is the alder-ash woodland (*Carici remotae-Fraxinetum*). This type of habitat belongs to the rarest plant communities of Europe. It consists of forest fragments in zones with springs or along the upper course of rivers. Within the Domain this type of vegetation occurs in two sectors in the western part, along the streamlet Amelsvonnebeek (sectors 43 and 44, see fig. 2). Overall these sectors have a high diversity, including many rare and unique Laboulbeniales (parasitic fungi on insects, De Kesel & Gerstmans 2011). In sector 53, which contains calcareous boulders that have been introduced there around 1940 for a rock garden, specific calciphilous lichens have been found, as well as the thermophilous moss *Grimmia torquata*, which has its only Flemish locality there (De Beer 2009). However, the undisputed champion of all sectors is number 67, which is situated along the castle lane, and harbours a high diversity of all investigated groups of organisms.

(Native) biodiversity and land use

It is well known that one of the main factors that influence biodiversity is land use. Within the Domain the main types of land use for the

The grounds of the Botanic Garden are divided into sectors, see the map on page 217.

Figure 2 Alder-ash woodland in sector 43 (Wild Meise). (Photo P. Borremans)

Figure 3 Six categories of land use in the Botanic Garden

W woodland

G grassland

D disturbed sectors

See the text (p. 210) for an explanation of the combinations of letters

sectors with more or less natural vegetation are woodland and grassland. For these sectors six categories of land use have been distinguished. Five categories of sectors were defined based on the proportion of woodland and grassland they contain: pure woodland; woodland with small parts of grassland; mixed woodland and grassland; grassland with small parts of woodland; and pure grassland. Moreover, a category was defined for highly disturbed or anthropogenically influenced sectors, such as sectors with plant nurseries, collections and buildings. Each sector was assigned to one of these six categories of land use, as shown in figure 3. Within the woodlands we did not distinguish between subcategories, as the management is rather similar in all woodlands in the Garden. It should be mentioned, however, that obvious differences in forest type occur according to species composition, hydrology, relief and soil type. Within the grasslands a further distinction was made according to the type of management, as discussed later.

Most of the sectors with the highest overall diversity in the Domain are mixed sectors with more or less equal proportions of woodland and grassland, or with a slight predominance of woodland. Mixed sectors also harbour the highest diversity of vascular plants, lichens and ectomycorrhizal fungi. An example is sector 67, which holds a high diversity for each group of organisms, but also for myxomycetes (fig. 4). Many of the sectors with an otherwise high diversity are pure woodland sectors and sectors with predominantly grassland. No sectors with a high anthropogenic influence show a high diversity, even though they are extremely important for lichens.

Individual organism groups are influenced by the land use in a different way. The highest diversity of myxomycetes is found in pure woodland stands. Indeed, the vast majority of these organisms live on dead wood. The highest number is found in stands with old trees where dead wood is left to decay in ancient forest (fig. 5).

On the other hand, epiphytic lichens prefer solitary trees and groups of trees as substrate, because such trees have higher light intensities on their trunks, the more so if the vegetation underneath is kept short. In the Domain many such small groups of trees lie scattered on

Figure 4. Sector 67 consists of mixed woodland and grassland, and has a high overall diversity. (Photo P. Borremans)

Figure 8. Sector 31 is a woodland rich in myxomycetes. (Photo P. Borremans)

Figure 9. Myxomycetes can proliferate on Rotterdam. (Photo P. Borremans)

lawns. They have been planted for ornamental reasons when laying out English style gardens, or later when the two castle estates were joined into a single park. Solitary trees also are common in the botanical collections of woody species, for example in the fruticetum (fig. 6).

Many lichens that are specialists of stony substrates have been recorded from the Domain. Indeed, old and undisturbed stony substrates are plentiful here, on buildings, walls and boulders. They often harbour many lichens (and mosses), some of which are unusual or even very rare in Flanders. This is also the case in sector 53, where calcareous boulders that were originally meant for a rock garden have been heaped up (fig. 7).

The Domain of the National Botanic Garden is extremely rich in mycorrhizal fungi. They grow mainly in forest fringes where the dead leaves are removed, so that the activity of deep digging earthworms is limited. The rare ectomycorrhizal fungi develop on dry patches under old beech and chestnut trees, such as in sector 29 (fig. 8).

Locations that are under strong human influence can also harbour an interesting biodiversity. This is the case for the inner courtyard of the herbarium building that contains specific vascular plants (Hoste & Geerinck 2011), but also a rich diatom flora, including two species new to science (Van de Vijver & Compère 2011) (fig. 9). This area has been left relatively undisturbed for two decades, although it is very much a man-made environment.

Grassland management

The type of grassland management was also found to influence the biodiversity in each sector. Since 2006, the grasslands within the Garden have been managed with a range of cutting regimes. These regimes include differences in the frequency, period and height of mowing. Utility lawns are kept short throughout the year, while natural grasslands are mown only once or twice a year, in July at the earliest. Woodland lawns are mown weekly, but only between July and September. In the sectors

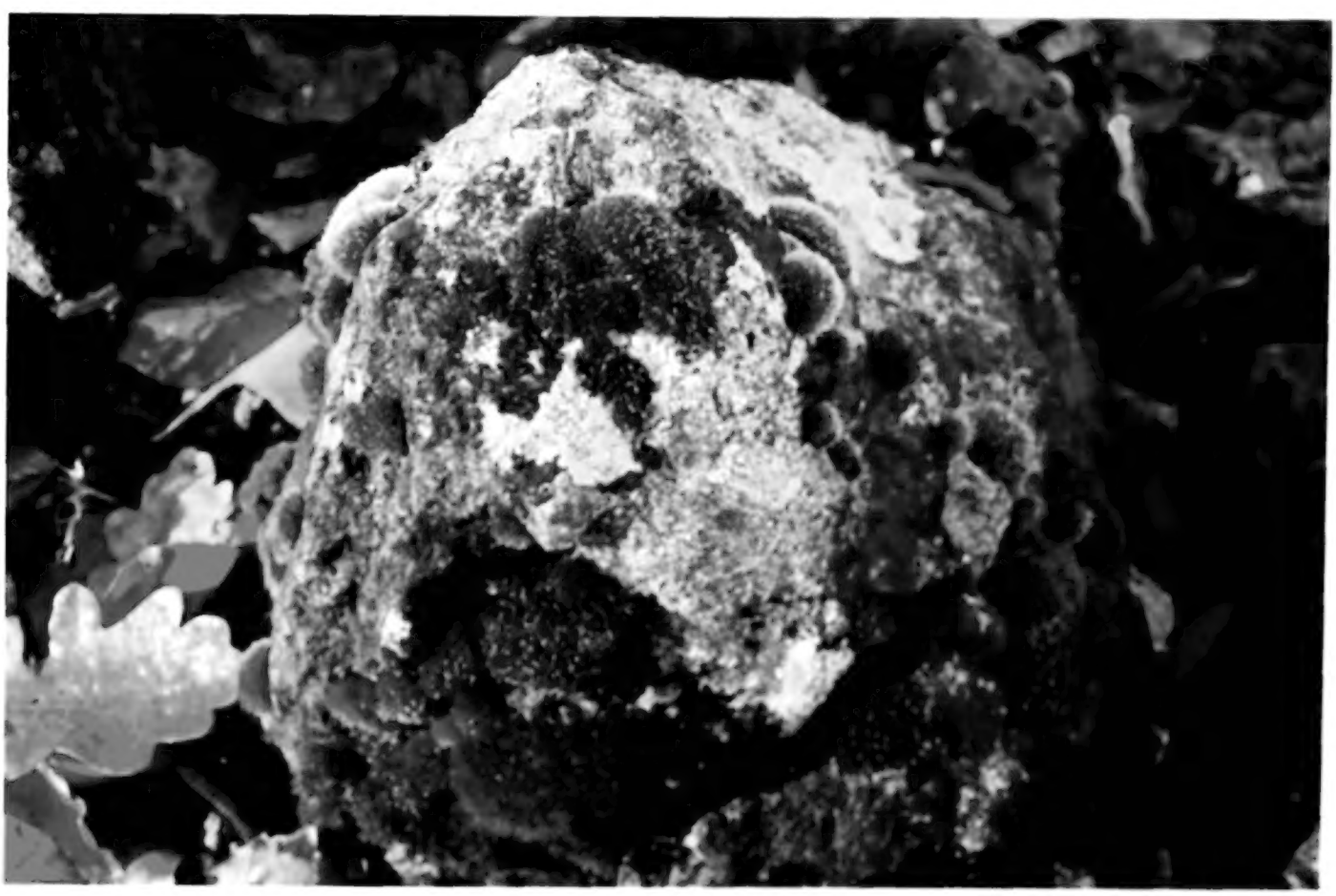


Figure 7. Calcareous boulders with lichens and mosses, sector 53. (Photo P. Borremans)

Figure 8. Old chestnut and beech trees in sector 29. (Photo O. Van de Kerckhove)

Figure 9. Ivy-covered wall and cliffs in the Leuvenum area. (Photo L. Vandekerckhove)

with the highest biodiversity, a large proportion of grasslands are managed as mixed utility lawns. These so-called mixed utility lawns typically contain high numbers of species of vascular plants and ectomycorrhizal fungi. An example of this is sector 13 where utility lawns are combined with natural grassland (fig. 10). The frequently cut utility lawns are usually less diverse. However, this changes completely when they are combined with patches of another management type. A second type of grassland with a high biodiversity is natural grassland. These grasslands contain many (rare) vascular plants, such as orchids and other species that thrive in hay meadows, and that cannot stand frequent mowing (fig. 11). On the other hand, woodland lawns have the lowest diversity. No sector with woodland lawns has a high overall diversity, and we also found an often lower diversity for all individual groups of organisms in this kind of lawns.

Recommendations for management

From the above mentioned findings some recommendations for the management of the Domain of the Botanic Garden can be formulated. These recommendations are solely based on the four well-studied taxonomic groups. Together they represent only a small part of the entire biodiversity. However, even for this restricted subset of groups of organisms, the validity of some recommendations varies from one group to another. This means that different management regimes will be needed for different locations in order to maximize biodiversity.

For vascular plants some general recommendations can be given, even if this group is very diverse, and even if they thrive in various habitats. As a whole, the diversity of land use and grassland management is advantageous for the vascular plant biodiversity. The use of herbicides should be minimized, particularly in conservation areas. Moreover, species worthy of conservation should be monitored. The invasive exotic species in the Botanic Garden with a potential to disrupt natural vegetation too should be monitored and controlled. Examples of species that currently cause problems are *Cornus sericea*, which is rapidly spreading in highly valued (semi-) natural habitats, *Heracleum mantegazzianum*, and *Fallopia japonica*, which very easily invades and overgrows or replaces existing vegetation. Finally, the impact of the grassland cutting regimes should be evaluated and adjusted. From our results it appears that the use of woodland lawns should be restricted, but the other types of grassland managed for conservation should be extended.

For myxomycetes it is very important that dead wood and litter remains in the woods so that it can decay in situ.

The very high diversity of lichens in the Domain is partly due to the high diversity of available substrates. For the conservation of lichens on stony substrates it is important to keep rocks and boulders free of higher plants, for example by planning the restoration of buildings and walls in different phases, so that parts of walls with interesting lichens are left intact; these parts can retain source populations for the colonization of cleaned parts. For epiphytic lichens old and large trees, on which specific species grow, are important, preferably without brambles or ivy covering the stems, and with short vegetation under the trees. For the terrestrial species the regular cleaning of roads is beneficial.

Ectomycorrhizal fungi thrive when fallen leaves are removed, and when the grassland under the trees is mown early, from April on. As they prefer old trees, the plantation of young mycorrhiza forming trees such as beech and chestnut, will ensure the replacement of the old trees that will perish in time.

Apart from this specific advice, some general recommendations can be given. For all groups of organisms it is important to restrict the use of fertilizers to the collections and nurseries, as large amounts of nutrients are detrimental to biodiversity. It is also important to minimize interventions in the existing hydrology of the Domain. It would furthermore be advisable to take some measures for the habitat improvement of animal organisms, such as allowing shrub layers to develop locally or leaving bramble patches in forests, and not removing dead and fallen trees.

Figure 10. Mixed utility lawns in sector 13, where utility lawns are side by side with natural grassland (Photo A. Rousset)

Figure 11. Mixed utility lawns in sector 13. Mowing does not always produce an attractive lawn (Photo P. Rousset)

Figure 12. The intensely managed and highly disturbed herbetum contains collections of herbaceous species (Photo A. Ronse)

Conclusion

The Domain of the Botanic Garden has a high conservation value, as it is both species-rich and contains a high proportion of rare species. This is the case for each taxonomic group studied so far, and it can be expected that the Garden will turn out to be a biodiversity hotspot for other taxonomic groups as well.

The biodiversity in the Domain is not concentrated in a single zone, but is scattered all over it. It is possible to designate some areas as especially rich in (rare) taxa, such as the swampy ash-alder forest and the adjacent grassland, as well as an area around the castle and the castle lane. However, all parts of the Domain contain interesting and rare species, even the more disturbed parts such as the botanical collections and the buildings. As a matter of fact, each group of organisms has different ecological requirements, and within each taxonomic group there are a variety of ecological preferences, so that each species occupies a different niche.

Different preferences are also found between groups of organisms according to land use and management. The highest biodiversity for all groups has been found in mixed situations: the most species-rich land use is mixed woodland and grassland, while the most species-rich type of grassland management consists of mixed utility lawns. The high diversity is also due to different degrees and types of disturbance in various areas, since nearly undisturbed areas such as woodland coexist with highly disturbed zones such as plant nurseries and collections, which are regularly weeded and cut (fig. 12). For each type of organism concise recommendations have been formulated that should allow maintenance or increase of their diversity. Some recommendations can be applied for all taxonomic groups.

Literature

De Beer D. (2009). Grimmia anodon (Musci, Grimmiaceae) nieuw voor België en vier nieuwe Grimmia-soorten voor Vlaanderen. *Dumortiera* **96**: 20-22.

De Kesel A. & Gerstmans C. (2011) — Laboulbeniales (Ascomycetes). *Scripta Bot. Belg.* **47**: 171-180.

Hoste I. & Geerinck D. (2011) — The vegetation of the enclosed courtyard of the herbarium building. *Scripta Bot. Belg.* **47**: 145-153.

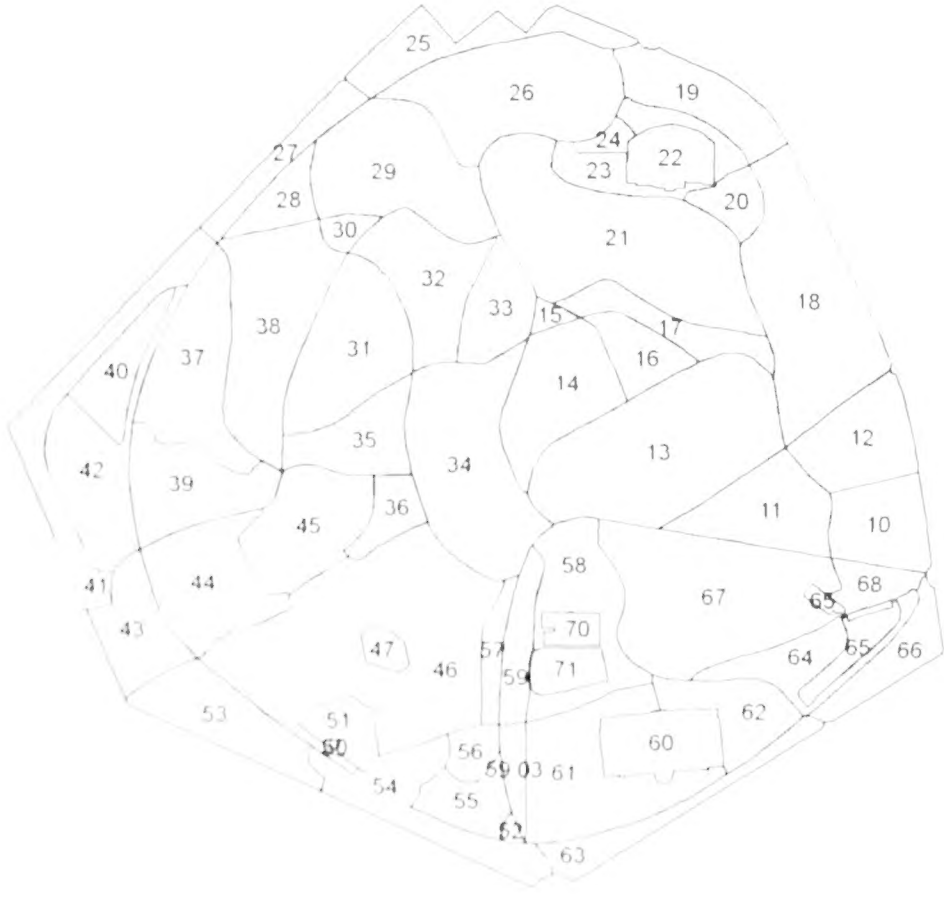
Ronse A. (2011) — The wild flora of the Botanic Garden: an introduction. *Scripta Bot. Belg.* **47**: 27-58.

Van de Kerckhove O. (2011) — Red List ectomycorrhizal fungi and their dependence on park management. *Scripta Bot. Belg.* **47**: 181-191.

Van de Vijver B. & Compère P. (2011) — Aquatic diatoms (Bacillariophyta) from a small pool at the herbarium building. *Scripta Bot. Belg.* **47**: 199-205.

Van den Broeck D. & Ertz D. (2011) — A lichen hot spot at fifteen kilometers from the center of Brussels. *Scripta Bot. Belg.* **47**: 159-170.

Annex. Map of the Domain of the National Botanic Garden of Belgium with location of the sectors.



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This volume contains 23 contributions and short notes dealing with the botanical and mycological diversity of the National Botanic Garden of Belgium. Almost all contributions have been written by people working at the Botanic Garden. Although animals have been largely neglected, this publication underscores the rich diversity of spontaneous wildlife within the grounds of the Garden, which covers 92 ha in the vicinity of Brussels. Moreover, this *Scripta* is intended to stimulate new efforts from both scientists and amateurs to further expand the inventory of the biodiversity of the Botanic Garden.

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